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<p>(54) Title: PATIENT/NURSE CALL SYSTEM</p>			
<p>(57) Abstract</p> <p>A patient/nurse call system (10) for a hospital includes patient stations (18) capable of generating hospital calls and a remote master station (32) which prioritizes and stores the calls. Hall units (28) outside patient rooms (14) identify the rooms (14) from which the calls originate and the type of call. Each patient station (18) allows selective retrieval and display of unanswered calls, and the system (10) further permits audio interconnection between any two of the stations (18, 32). Nurse-worn badges (26) transmit pulse-coded infrared signals which are received by receivers (121) at the patient stations (18) and in response, the system (10) generates identity and location signals which are stored at the master station (32). The nurse location and identity information may also be retrieved and displayed at any patient station (18). Receipt of a nurse's (11) infrared signal at a room station (18) automatically cancels a patient call originating from the room (14) and display thereof by the respective hall unit (28), while actuating a display (122) to indicate nurse (11) presence. By using the nurse call button (22), the patient can establish telephonic communications between the patient station (18) and a wireless telephone (64) being carried by a remotely located nurse.</p>			

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PATIENT/NURSE CALL SYSTEM

Field of the Invention

This invention relates to a hospital communication system, and more particularly, to a user friendly patient/nurse call system with enhanced operational capability.

5 Background of the Invention

Nurses and other staff in a hospital ward or hospital wing must work under varying conditions, which include high pressure, stress and long hours. These caregivers must remain alert to respond to patient needs, in emergency and nonemergency situations. Due to economic practicalities and the ever-increasing costs of medical care, it is necessary to make the most efficient use of nurses and staff on call in a hospital wing, particularly at night when nurse and staff levels are maintained at a minimum.

10 On the other hand, a desire to optimize the efficiency of nurse and staff personnel is of secondary importance relative to providing a high level of medical care. If nurse and staff levels are reduced to reduce costs without corresponding opportunities to improve efficiency, the level of patient care will decrease. One approach to maximizing the efficiency of nurses and other hospital staff involves the use of a location and identification system to continuously monitor the locations of these persons. For instance, White U.S. Patent No. 4,275,385 discloses a personnel locating system where individuals to be located wear infrared transmitters, and each transmitter transmits a pulse-coded signal which corresponds to the identity of the wearer. This information is relayed and displayed at a central control unit. This information may also be displayed at remote terminals, used to lock restricted-access equipment or locations, or conveyed via a telephone interface to a telephone switching network to call the nearest 15 telephone or to page the transmitter wearers.

20 Thus, to contact the transmitter-wearers, White requires that the location system interconnect with the telephone system and/or a paging system. This required interaction with another communication system increases the cost and complexity of interacting with the located personnel, due to the need for interfacing components. It also requires that personnel to be located either wear a receiving device, such as a pager, or that they be near a telephone.

25 A number of other U.S. Patents also disclose personnel locating or monitoring systems which purport to improve upon the system disclosed in the White patent. However, these improvements relate to the mechanics of signal detection, or the organization, maintenance and retrieval of stored information for making reports. These patents do not disclose use of a location system in a manner which helps nurses and staff do their jobs more efficiently and more effectively.

30 Almost every hospital wing or ward has a patient/nurse call system which includes an audio network to allow a patient in a hospital room to contact and speak with a nurse or staff member at a nurse station. Typically, the patient may activate a "call" signal by depressing a button on a small housing connected via hardwire to a unit mounted to the headwall of the patient room. This small housing is generally referred to as a pillow speaker, or pillow unit. The headwall unit usually has another wall-mounted call button for easy operation by a nurse. Other 35 input mechanisms may include emergency call buttons, code blue buttons, or bathroom call buttons. Additionally, the audio network of these call systems may be used for audio monitoring of a hospital room from the nurse station during an extreme emergency, such as a code "blue" status.

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Hospitals also include emergency signaling devices for notifying hospital personnel of other types of emergency conditions, such as smoke detectors or a fire alarm. Typically, these devices generate audio signals to convey audible alarms over a hospital intercom system, which may or may be interconnected with the patient room audio network. Some hospitals use bed monitoring devices with bed sensors which indicate bed conditions, such as "brakes on", mattress firmness (for inflatable mattresses), or incontinence. The duplicity of these call and information systems in a hospital complicates the organization, maintenance and effective dissemination of all of the useful information that is generated. If these systems cannot be operated in a simple, user-friendly manner, they can add to the stress level of nurses and staff. As a result, their jobs are made more difficult, rather than easier.

Additionally, use of multiple call and information systems in a hospital adds to the costs of health care, due to costs associated with purchase, installation and maintenance of the various components of these multiple systems, along with training personnel how to use the system.

Summary of the Invention

To overcome the disadvantages described above, the present invention provides a more advanced hospital communication system that maximizes the efficiency of nurses and staff on call in a hospital wing, but in a manner which does not increase the work load or stress levels of these professional caregivers. The hospital communications system of the present invention expands the operational capability of a patient/nurse call system, improves the overall effectiveness of a hospital personnel locating system, and simplifies the interaction with, and information retrieval from, a hospital communication system. The system of the present invention directly benefits nurses and staff by increasing efficiency and effectiveness and reducing stress levels. The hospital communications system of the present invention eliminates duplicity in communication systems used within a hospital, thereby to reduce the costs of purchase, installation and maintenance of the components of multiple systems, along with reducing the costs associated with training hospital staff in the use of multiple systems.

According to the principles of the present invention and in accordance with the described embodiments, a patient/nurse call system for a hospital wing includes a master station, a plurality of patient stations, (although referred to as "patient" stations, these stations may also be located in nurse or staff areas) and nurse-worn transmitter badges. A private branch exchange (PBX) system interconnects the master station and the other stations, and each room has an intra-room network. The intra-room network includes a hall unit mounted in the hall way and at least one patient station, at least one receiver, and inputs for generating digital signals related to calls or bed status information.

The master station provides communication capabilities for the other stations. It receives, stores and sends call information, instructions and status messages from the stations, and it controls and monitors all aspects of the system. The master station includes a console with a display, a control wheel and a handset. The master station further includes a personal computer with memory capacity for storing hospital calls and nurse location and identification information generated by the system.

Each patient station in a hospital room is associated with a single patient bed, although the system could also be configured so that each station would accommodate multiple beds. Each patient station includes a wall-mounted housing with a control wheel, a display, call generation/cancellation buttons, indicating lights and an audio speaker. Nurses at a patient station can readily retrieve stored, unanswered calls or nurse location information from the master station by operation of the user-friendly control wheel and display.

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The private branch exchange operates as a voice/data switching system for establishing audio links and data distribution between the master station and the other stations. The master station interconnects with the PBX via an RS-232 serial data line, and the PBX interconnects with each patient station via a twisted pair telephone line. The network for the system is basically a telephone network which provides synchronous, full duplex, voice and data communications between any two patient stations or between any patient station and the master station. It also allows two way audio links or connections between multiple pairs of stations. The PBX is a transparent device from the standpoint of signal content and interaction. It simply provides an audio and data communications link between any two stations upon request.

Each interaction between a patient station and the PBX is actually routed through an input/output board dedicated to the patient room in which the station is located. This I/O board routes all signals to or from the patient room, including generation of calls by input devices, display of calls at the hall unit associated with each room, and generation of a nurse identification signal in response to receipt of a pulse-coded signal from a nurse-worn badge. The I/O board controls the network associated with that patient room, i.e. the intra-room network.

When a PATIENT call is generated at a station, the I/O board signals the hall unit to illuminate a display light designated for PATIENT calls. The call is also routed to the master station via the PBX, where it is categorized according to priority and then stored. Preferably, the master station continuously displays all received and stored calls, and these calls are routed for display at any of the patient stations upon request at the patient station. Similarly, the nurse location and identify information can also be retrieved for display at each patient station via operation of the control wheel and the display.

The patient/nurse call system of the present invention generates and prioritizes all types of hospital calls and facilities answering of these calls from any one of a plurality of nurse stations or patient room stations in a hospital wing. The system has the capability of visually displaying all calls at any station, including stations located in the patient rooms, thereby to facilitate the dissemination of call information and to expedite responding to the calls.

Each patient room station interconnects to a plurality of input devices for generating the different calls used in a typical hospital, such as SMOKE ALARM, CODE BLUE, STAFF EMERGENCY, etc. These calls include patient-generated, nurse-generated or automatically generated calls. Calls may also be generated at one or more of the nurse stations. The calls are forwarded to a master station, which prioritizes the calls according to status and time received. Outside of each patient room, in the hall, a hall unit mounted above the doorway displays an indication that a call has originated from the room. The hall units connect directly to the patient room stations. Each patient room station preferably has a display and selection controls to allow retrieval and display of all calls. Thus, after responding to a call in a first patient room, a nurse at that patient station can retrieve and display the remaining calls and then respond to the highest priority unanswered call. The system also provides for audio interconnection between any two stations. This audio interconnection capability, along with the display of unanswered calls, facilitates oral communication among nurse, hospital staff and patients, thereby promoting efficiency in responding to calls.

Preferably, the nurses on duty in the hospital wing wear nurse locator badges, and these badges transmit pulsed-coded infrared signals to receivers operatively connected to the patient stations. In response, the patient stations generate corresponding identification signals unique to the wearer of the badge. The system then couples each identification signal with a location signal to form a signal pair, with the identification signal corresponding

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to the patient station of receipt. The signal pairs are automatically downloaded and stored at the master station. This nurse identification and location information may be displayed at the master station, or at any of the other stations. This allows a person at any station to visually display the identifications and locations of the nurses on duty in the wing, in addition to unanswered calls. This combination of display features optimizes the communication capabilities 5 among nurses, hospital staff and patients in a hospital wing. Thus, rather than serving primarily as a nurse monitoring system, as in some prior nurse locating systems, this system facilitates communication among nurses and staff and optimizes information flow to nurses and staff in a simple, user-friendly manner, thereby increasing efficiency and effectiveness.

In conjunction with the nurse locator badges, the system also provides for automatic resetting or cancelling 10 of "nonlatched" calls, for example, a patient call, and automatic cancelling of the visual display of the call by the respective hall unit, after a nurse wearing a badge is sensed by the respective patient station. Receipt of a nurse signal does not cancel higher priority "latched" calls, such as CODE BLUE, BATHROOM call. Preferably, a visual indicator at each patient station indicates that a call has been received. The respective hall unit also visually displays 15 nurse presence within the respective patient room. For purposes of this disclosure, a "latched" call requires the physical presence of a person at the location from which the call originated and that person performing a cancellation function, for example, pushing a cancel button, in order to reset the call. In contrast, a "nonlatched" call may be cancelled or reset automatically by the act of the call being answered or acknowledged which could be by a person 20 at the master station or a person answering the call with a telephone or by the patient station detecting the presence of a nurse.

In another mode, the nurse or any other person assigned to the patient can be out of the proximity of the 25 master station and a patient station and still be in communication with the patient. If the person has a telephone, the patient's room number is entered, and a voice communication link is established using the speaker and microphone on the patient station. Alternatively, a patient may initiate a call to a nurse using the nurse call button as described above, and if the nurse has a telephone, the patient call is routed to the nurse's telephone. Calls generated from equipment in the patient's room can also be routed to the nurse's telephone. The nurse receiving the 30 call has several options depending on the nature of the patient call. For example, the nurse can cause voice communication to be opened with the speaker on the patient station or, cause the system to establish a reminder call, etc. This mode makes the location of the caregiver invisible to the patient, and it allows the caregiver constant access to the patient regardless of location. In addition, the system has the advantage of not changing the protocol of communication for the patient. The patient does not require access to or the capability of using a telephone. The patient can always use the nurse call button, and patient station microphone and speaker regardless of the location 35 of the nurse or other assigned person.

This invention expands the operational capability of a patient/nurse call system to facilitate locating, prioritizing and responding to all types of hospital calls in a systematic way. Because of its simplicity in operation, this improved patient/nurse call system reduces the required amount of training time normally associated with learning a new communication system, in addition to reducing the stress level of nurses and staff on duty in a hospital wing.

This improved patient/nurse call system provides generation, storage, retrieval and display of hospital calls, 40 generation, storage, retrieval and display of nurse identity and location information, automatic display and cancelling of calls, an audio interconnection between any two stations, and multiple two way audio interconnections between

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station pairs. As a result, this invention reduces the overall hospital costs associated with installing and maintaining multiple systems with duplicative and/or overlapping capabilities, thereby resulting in a cost savings to the hospital.

These and other features and advantages of the present invention will become more readily apparent during the following detailed description, together with the drawings herein.

5 **Brief Description of the Drawings**

Fig. 1 is a perspective view of a portion of a hospital room which illustrates one patient station in a patient room and the physical arrangement of some of the other components of a patient/nurse call system in accordance with this invention.

10 Fig. 2 is a schematic which generally depicts the electrical interconnections among the components and stations of the patient/nurse call system of this invention.

Fig. 3 is a schematic which depicts the electrical wiring for a semi-private patient room interconnected to the patient/nurse call system of this invention.

Fig. 4 is a perspective view of a pulse transmitting badge for a patient/nurse call system constructed in accordance with this invention.

15 Fig. 5 is an electrical schematic of the badge shown in Fig. 4.

Fig. 6 is a perspective view of the pillow unit for a patient/nurse call system in accordance with this invention.

Fig. 7 is a perspective view of a patient station for a patient/nurse call system in accordance with this invention.

20 Fig. 8 is a perspective view of a hall unit for a patient/nurse call system in accordance with this invention.

Fig. 9 is a perspective view of a bath station or a shower station for a patient/nurse call system in accordance with this invention.

Fig. 10 is a schematic plan view which depicts a patient hospital bed for a patient/nurse call system in accordance with this invention.

25 Fig. 11a is an electrical schematic which shows the electrical connections among the components of the hall unit for a patient/nurse call system in accordance with this invention.

Fig. 11b is an electrical schematic which shows electrical connections among components of the patient station for a patient/nurse call system in accordance with this invention.

30 Fig. 11c is an electrical schematic which shows electrical connections among components of the bed receptacle controller for a patient/nurse call system in accordance with this invention.

Fig. 12 is a perspective view of a master station for a patient/nurse call system in accordance with this invention.

Fig. 13 is an electrical schematic of a portion of the master station for a patient/nurse call system in accordance with this invention.

35 Fig. 14 is a flowchart of a process by which a person can use a telephone to converse with a patient via the patient station.

Fig. 15 is a flowchart of a process by which a patient can use a nurse call button to initiate a conversation with another person having a telephone.

Detailed Description of the DrawingsI. The Calls

Before describing the detailed structure and operation of the patient/nurse call system of this invention, a review of the following table will familiarize the reader with the types of calls handled by the system and assist in understanding the system. The table identifies the calls generated by the system and provides an indication of how these calls are generated.

TABLE 1

	<u>CALLS</u>	<u>PRIORITY</u>	<u>GENERATED</u>
10	SMOKE ALARM	1	automatically/input device
	CODE BLUE	2	human operator/input device
	STAFF EMERGENCY	3	human operator/input device
	BATHROOM	4	human operator/input device
	SHOWER	4	human operator/input device
15	PATIENT EQUIPMENT i.e. Bed Status etc.	5	automatically/input device
	CHAIR	6	human operator/input device
	PRIORITY PATIENT	6	human operator/input device
	PATIENT	7	human operator/input device
20	STAFF	8	human operator/input device

A SMOKE ALARM call indicates sensed smoke, representing a fire hazard. A CODE BLUE represents an immediate life-threatening condition with respect to a patient. A STAFF EMERGENCY represents an urgent need by one nurse or staff member for assistance from one or more other nurses or staff members. A BATHROOM call is generated by a patient, and it indicates a higher priority of need than a normal PATIENT call, due to the increased possibility of danger or the more urgent need for assistance while in the bathroom. A SHOWER call is similar to a BATHROOM call, but it is generated at a different location in the bathroom of the patient room, i.e. the shower stall. A PATIENT EQUIPMENT calls represents a malfunctioning component of the system, or a status signal related to a patient or bed monitoring apparatus. A CHAIR call is basically a patient call generated remotely, as by an IR transmitter. A PRIORITY PATIENT call indicates that the call originated from one patient who is a member of a preferred class of patients, for one reason or another. A PATIENT call indicates a normal or standard patient call to the system. A STAFF call indicated a non-urgent call placed by a nurse or staff member.

II. The Hardware

Fig. 1 shows a physical layout of some of the components of a patient/nurse system 10 constructed in accordance with a preferred embodiment of the invention. A patient/nurse call system 10 of this invention organizes, stores, maintains and facilitates retrieval of the various calls placed in a hospital wing or ward, thereby optimizing communication capabilities among nurses 11 and patients 12.

More specifically, Fig. 1 shows a patient location in a room 14 accessible from a hall 15 of the hospital wing, and a hospital bed 16 located in the room 14. While only one bed is shown, the invention contemplates semi-private patient rooms 14, wherein two patient beds 16 are used. Additionally, if desired, the system 10 can be configured for more than two beds 16 in a single room 14. A patient station 18 is mounted to a head wall of the patient room 14.

The patient station 18 is connected by a hardwire connector 21 (not shown in Fig. 1) to a bed receptacle controller 20, with connector 21 located behind the headwall of the room 14. A pillow unit 22 connects via cable

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23 to a bed outlet or plug 23p of the receptacle 20. Additionally, a first end of a bed cable 24 plugs into a bed outlet or plug 24p of the receptacle 20, and a second end of the cable 24 connects to a bed status controller (not shown) for the hospital bed 16. Near outlet 20, cable 23 and cable 24 include switches 23s and 24s, respectively. These switches enable the cables 23 and 24 to be unplugged without generating an equipment alarm call, referred to as a
5 PATIENT EQUIPMENT call. Preferably, these switches are dual position for deactivating or activating an automatic alarm built into the outlet 20. The alarm is always activated unless the switch has been switched open. The alarm remains deactivated a predetermined number of seconds after switching, and then it reactivates. This automatic alarm for pillow units 22 is standard in many hospitals, and nurses 11 have come to instinctively pull the connector from the pillow unit 22 if they need help in a hurry. The switches 23s and 24s allow the system 10 to accommodate
10 this common practice.

Fig. 1 also shows a badge 26 worn by a nurse 11. The badge 26 clips to the outside of clothing worn by the nurse 11. The badge 26 transmits a pulse-coded signal, preferably infrared, which is received by a receiver 121 which is preferably located at the patient station 18, so that the system 10 can determine and continuously update locations of nurses 11 on duty within the hospital wing.

15 Fig. 2 schematically illustrates electrical connections among hardware components according to a preferred embodiment of the system 10. More specifically, Fig. 2 shows a plurality of patient locations each having its own patient station 18 which are interconnected with a master station 32 normally located remotely from the patient stations 18. At the master station 32, the system 10 stores location information about the nurses 11, information about hospital calls, information about hospital beds in use, the status of the hospital beds in use, instructions on how to operate the system 10, and a number of other features. The master station 32 classifies and displays the hospital calls according to priority status and according to time received. When the calls are retrieved by the patient stations 18, they are retrieved in this same order.

Structurally, the master station 32 includes a color LCD display 34, a video I/O card 36, a keyboard 40, a control wheel 176, an acoustic microphone 177, an acoustic speaker 178 and a handset 179 which interconnect with 25 a master station console 38. The master station console 38 serves as the interface between these components and a master station personal computer 43 which preferably includes memory, a hard drive (with at least 4M byte memory capacity), a floppy disc drive, parallel ports, serial ports and a power supply. A keyboard cable 45 interconnects the master station console 38 with a video adapter 47, preferably a Yamaha card. A coaxial cable 48 supplies electrical power to master console 38 and these components, and cable 48 interconnects the video interface 30 36 with the video adapter 47, via master station console 38. Another electrical cable 50 interconnects the master station console 38 with a loader card 52 in the personal computer 43, and cable 50 includes two audio (2B+2D) channels in a single, eight conductor wire. The master station 32 is physically located at a staff station in the hospital wing, a nurse station of the hospital wing or a general office for the hospital wing.

The personal computer 43 of the master station 32 interconnects via cables 55, 56, 57, 59 and 61 to other 35 processors and components of the system, which are preferably located within an equipment closet or cabinet 53 in the hospital wing. The components located within the equipment cabinet 53 include a card cage 54 for locating power distribution cards (not shown) and preferably an expandable "DXP" private branch exchange ("PBX") 65, which is commercially available from Comdial Corporation of Charlottesville, Virginia. The "DXP" PBX is a voice/data switch, and it contains the necessary hardware and software to allocate point-to-point audio links and to 40 distribute data in the form of messages from the master station 32 to the patient stations 18, and vice versa. Cable

55 includes three audio (2B+2D) channels in a single, eight conductor wire and is connected to the card cage 54. Cables 56 and 57 are RS-232 lines interconnecting the master PC 43 and the "DXP" PBX 65. An analog interface for an industry standard telephone is preferably provided by two analog-to-digital port converters 58, 60 connected in lines 59, 61, respectively. The port converters 58, 60 make the digital ports on the "DXP" PBX 65 appear as
5 analog ports to a the voice card 51 in the master PC 43. The analog-to-digital port converters 58, 60 are preferably units compatible with the "DXP" PBX which are commercially available from Comdial Corporation of Charlottesville, Virginia; and the voice card is preferably model no. D/41D commercially available from Dialogic Corp. of Parsippany, New Jersey. The "DXP" PBX 65 is connected by one or more trunk lines 62 to a hospital PBX
10 63. The hospital PBX 63 then functions to establish either wired or wireless communication with a caregiver telephone 64.

15 The master station 32 occupies three audio stations. The "DXP" PBX 65 can connect five 15-channel cards, or seventy-seven patient stations plus the master station 32. Each power distribution card in the card cage 54 can connect a maximum of sixteen audio stations. An expanded "DXP" PBX 65 and cabinet 53 can allow a total of one hundred and ninety-two audio stations or one hundred and eighty nine patient stations 18 plus one master station
15 32 (which requires three audio lines). This expanded capability requires one "DXP" PBX 65 with an expansion cabinet (not shown) and twelve power distribution cards. Eventually, interconnection of additional master stations 32 could further expand the capability of the system 10. Power supply 66 supplies electrical power to the "DXP"
20 PBX 65. Power supply 64 and a battery backup 67 are connected to card cage 54 and supply electrical power to the other components in the cabinet 53.

25 20 An electrical cable 68 connects one of the power distribution cards of the card cage 54 to a patient room I/O board 70. Each hospital room 14 in the hospital wing includes an I/O board 70, and this I/O board 70 includes multiple connections and inputs for generating calls from the room 14. Figure 2 shows patient room 14a connected to card cage 54 via cable 68a, and patient rooms 14b and 14c connected via cables 68b and 68c, respectively. The I/O board 70 and its interconnected components comprise the intra-room network. Communication among
25 components connected to I/O board 70 occurs over two wire, half duplex, multidrop EIA RS-485 standard, with message exchange being peer to peer. Any device on the intra-room network can send data to any other device without waiting for a poll. The intra-room network is not transformer isolated.

30 30 Each patient station 18 interfaces with the "DXP" PBX 65 over a two-wire twisted pair network (Motorola UDLT 2B+2D), and messages are transmitted and received between the stations 18 and the "DXP" PBX 65 over the D-channel. Messages received by the "DXP" PBX 65 from the patient stations 18 are transmitted to the master station PC 43, and messages received by patient stations 18 originate at the master station PC 43. Patient stations 18 cannot send messages directly to each other. A patient station 18 and/or the master station PC 43 can transmit a message at any time. At the master station PC 43, a COMDIAL-supplied library called the ENTERPRZ handles the interface with the "DXP" PBX 65. All messages that the system 10 wishes to pass to a patient station 18 are converted to a form that the ENTERPRZ library can accept. The ENTERPRZ library has only one function, for passing messages to stations 18 on the network. This function can only accept 16 bytes of information at a time, and the bytes must be printable ASCII characters. The destination address is also passed as part of this function. The ENTERPRZ library then embeds this information into it's own link-level protocol, with it's own control information, including destination, address and checksum, etc., and sends it as a packet to the "DXP" PBX 65.
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With respect to patient room 14a shown in Fig. 2, patient stations 18a and 18b connect to the I/O board 70 via cables 71a and 71b, respectively. Bed receptacles 20a and 20b connect to stations 18a and 18b via cables 21a and 21b, respectively. Cable 24a interconnects a bed status controller 72a to the bed receptacle 20a, and cable 23a connects the pillow unit 22a to the bed receptacle 20a. Patient station 18b includes similar connections.

5 Additionally, hall unit 28 connects to the I/O board 70 via connector 73. Bath, or bathroom, station 74 connects to I/O board 70 via connector 76. Shower station 78 connects to I/O board 70 via connector 79. Remote code station 81 connects to I/O board 70 via connector 82. Remote staff station 84 connects to I/O board 70 via connector 85. Bath station 74, shower station 78, remote code station 81 and remote staff station 84 are adapted to be actuated to generate BATHROOM, SHOWER, CODE BLUE and STAFF calls, respectively, to the system 10 from patient room 14a. With respect to bathroom station 74 and shower station 78, the calls generated are assigned a higher priority than a normal patient call generated by the button on the pillow speaker. This is due to the increased urgency associated with a patient's need for help when in the bathroom, and an even higher need for urgency when in the shower. Remote code station 81 generates a code blue call. Remote staff station 84 generates a staff call. Additionally, each of patient stations 18a and 18b also permits generation of a CODE BLUE call and a STAFF EMERGENCY call.

10 Fig. 2 also shows one of the nurse-worn badges 26 which communicates with the patient station 18a via infrared signaling. The system 10 may include a chair call device 86 which also communicates with the patient station 18 via pulsed infrared signaling. The chair call device 86 may be used by a patient 12 to generate a call, designated a CHAIR call, when he or she is away from the pillow unit 22.

15 Fig. 3 is a schematic wiring diagram which shows the connections between the master station 32 and a patient room 14, but in somewhat more detail than Fig. 2. More specifically, Fig. 3 shows one of the power distribution cards 87 housed within card cage 54 (Fig. 2). Each power distribution card 87 includes sixteen one-channel ports 87a, five three-channel ports 87b, eight two-channel ports 87c, a data port 87d which connects to the "DXP" PBX 65, and four parallel power ports 87e. Distribution card 87 also includes a plurality, preferably 20, one-amp fuses (not shown) with each fuse corresponding to one of the single channel parts 87a. Preferably, cable 55 connects the bottommost of the single channel ports 87a to the loader card 52. In this configuration, the two lowest two-channel ports 87c cannot be used. Moving upwardly from the bottommost of the one-channel ports 87a, the next three ports are designated loader, master voice, and master monitor. The uppermost of the one-channel ports 87a is designated as a booster port.

20 The ports of the power distribution card 87 designate the addresses for the patient stations 18. Between the power distribution cards 87 and the various stations 18 within the room 14, i.e., the intra-room network, the call signals and nurse information signals do not include an address or a location signal. When calls are generated within the patient rooms 14, each call is routed to the distribution card 87 via the port designated for that specific station 18, and the signal is further conveyed from the power distribution card 87 to the master station 32, but with a signal address appended thereto by the "DXP" PBX 65 to designate the specific station 18. Signalling between the "DXP" PBX 65, the loader card 52 and the master station 32 is via a serial data string on an RS-232 line, and each data string includes call information (or nurse location information) combined with location information related to a particular patient station 18. The interconnection between the loader card 52 and the bottommost of the single channel ports 87a is used to download software instructions from the master station 32 to the I/O boards 70 and the stations 18. This feature will be described in more detail in a later section.

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As shown in Fig. 3, the I/O board 70 for a patient room 14 provides an interface between the power distribution cards 87 and the stations 18 and hall units 28. More specifically, each I/O board 70 includes a plurality of ports 70a, each of which may be connected via a cable 71 to a patient station 18. Additional output ports 70b are configured to be connectable to the hall unit 28 via a connector 73. Ports 70a or 70b may also be used for one or more additional stations such as a bath station 74, a shower station 78, remote code station 81 or remote staff station 84, depending upon the needs of the particular hospital wing.

Fig. 4 is a perspective view of a transmitting badge 26 worn by nurses 11 assigned for duty within the hospital wing, in accordance with a preferred embodiment of the invention. The badge 26 includes a housing 90, which is preferably made of molded plastic, two light emitting diodes 92 for transmitting pulse-coded infrared signals, and a spring biased clip 94 which enables the badge 26 to be clipped to the clothing of the nurse 11. The badge 26 weighs about one ounce and it is approximately 2.75" x 1.25" x 0.5". The badge 26 transmits a pulse-coded, modulated infrared packet every six to eight seconds. The pulses are of fixed length and fixed amplitude.

Fig. 5 is an electrical circuit schematic which shows the components and interconnections among the components of the badge 26, which preferably transmits pulsed-coded infrared signals ($\approx 940\text{nm}$ wavelength). According to the invention, a pulse or lack of a pulse within a prescribed time slot represents either a logic 1 or a logic 0. A pulse (logic 1) comprises several cycles of a 36 KHz signal. Each packet comprises 33 total bits, including a start bit, 16 data bits and 16 inverted data bits. Transmission of the inverted 16 data bits insures integrity of the packet. If desired, additional start bits may be used. Use of 16 data bits allows for 65,535 unique code numbers. Some of the code numbers may be reserved for future applications, while a number of the code numbers are dedicated solely for the purpose of nurse identification. The 16 data bits which identify the particular badge 26 are preferably stored internally in an EPROM located in the badge 26.

The following table identifies internal components of the badge 26 which applicant has used successfully.

TABLE II

	MANUFACTURER	MODEL #	ITEM	DESIGNATION #
25	MicroChip	PIC16C54	Microcontroller	95
	Sanyo	CR2450	Battery	96
	Siemens	SFH415-U	IR LEDs (2)	92
	Motorola	MTD305SEL	FET	97
30	Illinois Cap.	470uF6VDC	Transistor (3)	98
	National	2N2222	Transistor	99
	Murata Erie	2Mhz	Resonator	100

These components are mounted on a printed board, which may be a PCB made by DSI. The microcontroller 95 has a power saving mode (about 14 microamps) that is referred to as "sleep". During sleep, a watchdog timer continues to run and will "wake up" the microcontroller 95 after approximately two seconds. Since the badge 26 transmits the signal approximately every six seconds, there is a sleep count register initially set to two spaces. Each time the microcontroller 95 "wakes up", it checks the sleep count register to determine if six seconds have expired. If six seconds have not expired, the microcontroller 95 decrements the sleep count and goes back to sleep. If six seconds have expired, i.e., the sleep count is zero, and the microcontroller 95 reads the 26 bits of internal memory that contain the encoded identification number. Initially, the start or parity bit is clocked out and is then followed by the 26 data bits. The microcontroller 95 generates the 36 KHz carrier and the timing for each bit. The field effect transistor 97 and the transistor 99 drive the two LEDs 92 which emit the infrared signal packet. After a packet has

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been sent, the sleep count is reinitialized and the microcontroller 95 goes back to sleep. If it is desired to transmit from the badge 26 less frequently, perhaps every eight seconds, the sleep count register is initially set to three spaces. The battery 96 for the badge 26 is designed to operate continuously for four months. The particular battery 96 chosen for this badge 26 requires an industrial grade (500 mAh +) CR-2450, due to its power capabilities. The chair call 86 can be made by modifying the circuitry of the badge 26 to include an OFF/ON switch so that transmission is not continuous, and by programming a different code, i.e., a CHAIR call, into an EPROM housed therein.

Fig. 6 shows a perspective view of a pillow unit 22. The pillow unit 22 operatively connects to outlet 20 via connector 23. The pillow unit 22 includes a molded plastic housing 103, acoustical speaker 104 and a nurse call button 105. Depression of nurse call button 105 generates a patient call from the respective patient station 18. Preferably, the pillow unit 22 further includes a television on/off power button 106, channel selectors 107 and light switches 108. Additional controls may include light dim switches and television volume controls. These signals may be transmitted along conductors routed within connector 23, or they may be IR signals.

Fig. 7 shows a perspective view of the patient station 18. The patient station includes a molded housing 112 which connects to the head wall, preferably by screws. A voice microphone 113 is located on the right side of the housing 112, and an audio speaker 114 resides on the left side of the housing 112. Pushbutton 115 generates a "latched" staff emergency call, and pushbutton 116 cancels the call. Control wheel 117 operates in conjunction with a display 118 to control retrieval of information from the master station 32 for display at the patient station 18. Preferably, the display 118 is a two-line by sixteen character LCD display.

More specifically, display 18 includes a cursor which points to one of three designations, STATION, 20 STAFF, WAITING CALL. Rotation of the control wheel 117 moves the cursor between these three designations. With the cursor pointing at one of the designations, depression of the control wheel 117 selects the function represented by that designation. If WAITING CALL is selected, the patient station 18 displays the unanswered calls stored in the system 10 at the master station 32. Because of the limited amount of space on display 118, the user must rotate control wheel 117 to scroll the waiting calls. If STAFF is selected, the display 118 visually indicates 25 all staff presently on duty in the hospital wing, plus the current, stored location information for the nurses 11 derived from the badges 26. If STATION is selected, a STAFF call is initiated. The user interface for the patient station 18 is menu driven, and this interface is more fully explained in Appendix B of Section III, entitled "Operation".

The patient station 18 further includes a receiver 121 adapted to receive the pulse-coded signals transmitted from the badges 26 and thereby generate location signals for nurses 11 wearing the badges 26. If desired, the housing 30 112 may also include one or more LEDs 122 which indicate one or more of the following conditions, a call placed from the station 18, audio channel open to the station 18 or receipt of an IR signal from a badge 26. The microcontroller connected to the receiver 121 performs three tasks. It receives, decodes and validates pulsed signals from the badges 26. It maintains the status of the identification signals generated in response to receipt of the IR signals, and communicates the status information to the other components of the intra-room network for the particular 35 station 18, namely, one of the indicator lights on housing 112, the indicator lights 126 or 127 at hall unit 128, and input/output board 70.

Upon initial receipt of a signal from a badge 26, a microcontroller of the receiver 121 starts a bit timer (after delaying for one half of a valid bit width). After the bit timer expires, the receiver 121 samples the signal from the front end. If the signal is HIGH, the bit is a 1, if the signal is LOW, the bit is 0. Sampling continues for all consecutive bits. The microcontroller must receive a thirteen bit string which is matched by a subsequent thirteen

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bit string, but inverted, for the packet to be valid. If a start bit is received but no data or invalid data is received, receiver 121 considers this to be noise or a "packet collisions" between other badges 26 and no signals are validated.

For each valid identification signal received, a separate timer keeps track of its presence. Each time an existing identification signal is received, the timer for that signal is reset to zero. If the timer reaches thirteen seconds without receiving a subsequent signal, i.e., two consecutive transmissions if transmission occurs every six seconds, the system 10 assumes that the nurse 11 wearing that badge 26 has left the room 14, and that particular identification signal is deleted from the table. If there is at least one identification signal registered for a room 14, and an invalid packet is received, the software for the receiver 121 assumes that the received invalid signal was an attempt to update the table. As a result, for each of the identification signals in the table, the timer is set to zero as if a valid packet has been received. However, this may only happen once before another valid signal is received. Otherwise, receiver 121 deletes the identification signal from the table. Thus, normal operation requires that the nurse 11 be out of the room 14 for a maximum of thirteen seconds before "checking the nurse out" i.e., deleting him or her from the table, or upon receipt of the nurse's signal at another station, whichever occurs first.

The top of housing 112 includes a lever 120 for generating a CODE BLUE call. Preferably, the lever 120 is pulled to initiate a CODE BLUE call. The lever maintains the pulled position. A CODE BLUE call is cancelled by first, pushing the lever 120 back to its original position and second, pushing the CANCEL pushbutton 116. The design and arrangement of the components of the patient station 18 facilitates nurse 11 interaction with this patient/nurse call system 10. Use of nurse locating badges 26 in combination with the display 118 and the control wheel 117 optimizes information flow and verbal exchanges among nurses 11 on duty within a hospital wing. Thus, the system 10 utilizes nurse locator badges 26 to help nurses 11 become more efficient in their duties, rather than simply monitoring their whereabouts. Although the receiver 121 is mounted within housing 112 of a patient station 18, it may be physically removed therefrom and placed in a more convenient location for detecting signals from the badges 26, if desired. The receiver 121 is preferably an infrared receiver, (such as a Siemens Model Number SFH-506-36), which provides automatic gain control, band pass filtering, demodulation and wave shaping. Thus, the output of receiver 121 may be routed directly to an interrupt input of a microcontroller (not shown) for the patient room 14. The receiver 121 maintains a table of all badges 26 located in the room 14. When a badge exits a room 14, the receiver 121 adjusts the table and informs the system 10 of the change. Because this table is maintained locally, i.e., at the locator receiver, only changes in the table are signaled to the station 18 and the rest of the system 10.

Fig. 8 shows a hall unit 28 located outside each patient room 14 in the hospital wing. The hall unit 28 includes a molded housing 124, which includes a base or mounting plate 125 and a protruding section 128 which includes indicator lights 126 and 127 for indicating when patient calls have been generated at patient stations 18a and 18b, respectively, and an indicating light 132 which illuminates upon generation of a CODE BLUE call, a STAFF EMERGENCY call, a BATHROOM call or a SHOWER call. Preferably, indicating light 132 flashes according to one of a number of different predetermined patterns or sequences, with each pattern dedicated one of these "higher priority" calls. Additionally, an audible alarm may also sound to indicate one of these higher priority calls.

An indicating light 130 illuminates when a signal from a badge 26 has been received by the receiver 121. Preferably, upon receipt by the receiver 121 of an infrared signal from a badge 26, the patient station 18 automatically cancels any PATIENT call placed from that particular station 18. This cancels illumination of

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indicating light 126 or 127, depending upon the particular station 18. Thus, nurse presence in the room 14 is indicated via illumination of an indicating light 130 located in the hall 15 and/or another indicating light mounted to housing 112 at the station 18.

Additionally, each of the lights of the hall units 28 may include a test button which, when depressed, actuates the lights, thereby to indicate to nurses that the hall unit 28 is operating correctly. Alternatively, an LED associated with each light of the hall unit may activate upon sensing a burnt out condition. If desired, this signal may also be conveyed to the master station 32. Fig. 9 shows a bathroom station 74. Preferably, the station 74 includes a housing 134, a pull bar 135 and a slide 136 connected to the pull bar 135. A patient's pulling of the pull bar 135 will initiate a BATHROOM call, or a SHOWER call. If it desired that the call be a "latched", that is, one that cannot be cancelled by the act of answering the call, the station 74 may also include a pushbutton 137 for cancelling the call.

Fig. 10 shows a hospital bed 16 interconnected with the patient/nurse call system 10 of this invention. The bed 16 includes a headboard 140, a footboard 141, head siderails 143, foot siderails 144 and a mattress having head and foot ends 146 and 148, respectively. The mattress may be covered intermediate ends 146 and 148 by an incontinence detection pad 147. The mattress preferably can be inflatable and can be raised, lowered or anchored. Bed 16 also includes a plurality of sensors which sense conditions in the bed 16. These conditions may include, but are not limited to, ground fault, bed down, brake not set, bed power, head or foot end raised 30° or higher for longer than a prescribed time, mattress excessive air loss, bed exit armed, bed exited, head or foot siderails latched or incontinence detected, as disclosed in applicant's co-pending U.S. Patent Application Serial No. 08/145,767, filed on 10-29-93, entitled Incontinence Detection Device, which is expressly incorporated by reference herein in its entirety.

All of the bed status sensors generate signals which are fed to a bed control unit 149. This control unit 149 may include visual displays for indicating the status of the bed 16 at the footboard 141. In accordance with this invention, the bed control unit 149 also connects, via cable 24, to the bed outlet 20, and the bed status signals are transmitted to master station 32 for storage and subsequent retrieval. An operator at the master station 32 may determine the status of each of the bed conditions and react accordingly, if necessary. Preferably, each bed 16 also has a serial number assigned thereto during manufacture. This serial number may be read from the bed 16 to the master station 10 so that the system 10 can keep track of the location and amount of use for each bed 16, and/or maintenance performed or needed over the useful life.

Fig. 11A shows electrical connections for components of I/O board 70. More specifically, the I/O board 70 includes a receptacle 150 which interconnects with the "DXP" PBX 65. RJ45 Receptacles 151a, 151b and 151c are adapted to be connected with inputs from patient station 18a, 18b and 18c, respectively (for a room with three stations). An additional receptacle 151d is reserved for a spare room bus. If a patient room 14 only includes two stations 18, the receptacle 151c would serve as an additional spare. The I/O board 70 further includes a microcontroller 152 and additional RJ45 receptacles 151e, 151f, 151g, 151h, 151i and 151j for interconnection with the hall unit, an additional CODE BLUE station, a BATHROOM, (or TOILET) station, the SHOWER station, the STAFF EMERGENCY station and the SMOKE ALARM station, respectively. In conjunction with a transceiver 153, the microcontroller 152 communicates with the stations 18a, 18b and 18c to control operation of lamp drivers 154 which control actuation of the lights, 126, 127, 130 and 132 at the hall unit 28.

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Fig. 11A also shows that a CODE BLUE receptacle 151f, the BATHROOM receptacle 151g, the SHOWER receptacle 151h and the STAFF EMERGENCY receptacle 151i also interconnect with hall unit receptacle 151e and LED drivers 155. This permits actuation of light 132 at the hall unit 28 upon generation of a CODE BLUE call, a BATHROOM call, a SHOWER call or a STAFF EMERGENCY call, respectively from the patient room 14. The microcontroller 152 and LED drivers 155 control operation of light 132 so that it flashes according to a predetermined sequence which is unique to the type of "higher priority" call which has been generated. Thus, a nurse 11 in the hallway 15 may readily determine which of these "higher priority" calls has been generated from the room 14. In addition to flashing of light 132 according to a predetermined sequence which corresponds to the high priority call that has been generated, an audible alarm may also be sounded, with the sounds actuated according to tone and/or sequence in a predetermined manner, thus enabling a nurse 11 to audibly identify which type of high priority call has been generated from the room 14.

Fig. 11B shows the electrical interconnections at each of the patient stations 18. Operations at the patient station 18 are controlled by a microcontroller 162 which communicates with other components of the I/O board 70 via a transceiver 163. Preferably, the microcontroller 162 is an Intel 87C52, and the transceiver 163 is a Linear Tech LEC485. Microcontroller 162 of the patient station 18 controls operation of the inputs and the outputs mounted to housing 112. Patient station 18 also includes a random access memory designated 164, and a micromonitor 165, which is preferably a Dallas DS1232.

Fig. 12 shows a perspective view of a master station 32 for the patient/nurse call system 10 of this invention. The master station 32 includes a display 34, which is preferably a color liquid crystal display, a retractable keyboard 40 which slides underneath the control panel 174, a rotatable control wheel 176 which mounts to the panel 174, an audio microphone 177 and an audio speaker 178 which also mounts to the panel 174. Master station 32 also includes a handset 179. With calls displayed on display 34, lifting the handset 179 initiates an audio link with the patient station 18 which generates the highest priority call stored at the master station 32. If the control wheel 176 is rotated to "highlight" a different call, depressing the control wheel 176 will open a two way audio link with the patient station 18 which generated the "highlighted" call. The control wheel 176 can also be rotated to highlight the telephone handset pushbutton 181, and depressing the control wheel 176 initiates a phone call mode. Thereafter, a menu appears on the screen which requires the user to select the type of call to be made, for example, Patient, Location, Staff or Staff Telephone. If Patient is chosen, patient names are listed on the screen. The control wheel is rotated to highlight the name of a patient on the screen and then, depressing the control wheel will open a two way audio link between the master station 32 and the selected patient station 18. If Location is chosen, a list of locations is displayed on the screen; and the control wheel is used to select the desired location, afterwhich a voice communications channel is opened between the master station and a patient station at that location. If Staff is chosen, a list of staff names is displayed on the screen. Upon using the control wheel 176 to chose a staff name, the system determines the most recent location of that person and opens a voice communication channel between the master station and the patient station at that location. If Staff Telephone is chosen, a list of staff names who have telephones is displayed on the screen. The control wheel is then used to select a staff name; and as will be described in more detail, the system automatically enters the telephone number of the selected staff in order to provide a communication channel using the master station and the staff member's telephone.

Fig. 13 shows electrical interconnections among the non-video components at the master station 32. Block 184 designates the control logic for controlling operations at the master station 32. This includes a programmable

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microcontroller, an EPROM, a RAM, and customized ASIC which, together, control overall operation of the system 10. This control logic interfaces with a pair of transformers 188 mounted on the loader card 52. The microcontroller 186 further connects to a hook switch 190, a handset 179 and microphone 177 via an audio ringing code filter 192, two audio speakers 178 via a second audio ringing code filter 194, an analog/multiplex switch 195 and an audio amplifier 196. Volume control 198 enables an operator at the master station 32 to control volume of the speaker 178 with a microphone 177.

III. Operation

At startup, the operational software which actually controls the patient station 18 is dynamically downloaded from the master station 32. This allows software updates and modifications to be implemented without having to change a PROM in the patient stations 18. All patient stations 18 have a small program called the LOADER which is permanently stored in the 8K of program space on the 8752 microprocessor that serves as the CPU for each station. The main function of the LOADER program is to receive the downloaded operational software, which is stored in the 64K of RAM space of the patient station 18 as it is received. When the download is complete, the LOADER program first performs a checksum test to determine if the downloaded software is error-free, and if so, then switches the processor's program execution area to RAM, thereby beginning execution of the downloaded program. This allows for the running of a much larger program than could fit into the 8752's on-chip program area. Currently, the RAM executable program area is configured to be approximately 48K in size, with an additional 16K of RAM reserved for data space.

Three hardware/software components are involved in the download process (in addition to the "DXP" PBX 65), as well as three data channels. The hardware/software components are the patient station 18, the loader card 52 and the master station PC 43. The data channels are the D-channel, the B-channel, and the RS-232 serial data link. The loader card 52 resides in the master station PC 43 and communicates therewith over the RS-232 link. It also communicates with the "DXP" PBX 65. To the "DXP" PBX 65, it looks like just another patient station 18. The binary image of the software to be downloaded to the patient station 18 is first transmitted to the loader card 52 over the serial data link. The loader card 52, upon receipt of the appropriate command from the master station PC 43, then transmits the binary image of the station software over the B-channel, which operates normally as the audio channel and which is much faster than the D-channel. The D-channel is used by all three components for synchronization and control. The loader card 52 communicates with the master station PC 43 over a serial data link. Actually, the loader card 52 looks like a serial adapter card to the master station PC 43 and is configured to communicate with the master station PC 43 over the COM-4 channel at 19.2k baud, with 8 data bits, no parity bits, and 1 stop bit.

When the application software for the system 10 boots up on the master station PC 43, it looks for a file called "SEND.BIN" in the default directory. This file is a binary image of the downloadable station software. It is transmitted to the loader card 52 in 256 byte blocks, plus a relatively small header block at the start. This transmission is essentially performed in the background, so that the system 10 can perform other functions at the same time. The downloading to the loader card 52 usually takes about 30 seconds. When the loader card 52 receives the last block, it calculates an EXCLUSIVE-OR sum and a normal sum of a data received and compares the 2 sums with the 2 received checksums. If they match, it sends back an ASCII 'O' followed by an ASCII 'OR' to the software

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of the master station 32. This constitutes an acknowledgement and the master station 32 considers the loader card 52 ready to download to the patient stations 18. The loader card 52 now has the binary image.

In the downloading process, the D-channel is used for synchronization and control, as well as for requests and responses. When a patient station 18 is first powered up, it performs a test to determine if it has downloaded 5 software present (RAM is kept electrically charged for a few hours when there is no power to the station 18, so the station 18 software in RAM can be retained with no power) and performs a checksum test to determine if the software is valid. If so, the station 18 begins running the software in RAM. If it has no software in RAM or determines that the software is invalid, it begins sending 'download request' messages over the D-channel, to the master station 32. By default, these requests are sent once every 60 seconds. When the software at the master 10 station 32 receives a request, if it is not currently waiting for a download to another station 18 to complete, it initiates the download process by sending a 'prepare for download' message to the station 18 and then sending a 'begin download' message to the loader card 52. It then opens a special voice channel between the station 18 and the loader card 52 to transmit the binary data from the loader card 52 to the patient station 18.

When the station 18 receives a 'prepare for download' message it sets a timer allowing about 15 seconds 15 for completion of the downloading. If the station 18 receives the complete download, it resets the timer, and then performs a checksum test on the downloaded software which it now has sorted in RAM. If the test passes, the station 18 sends back a D-channel 'download successful response' message to the software of the master station 32, and the station 18 switches execution to the software in RAM. If the checksum test fails or if the station 18 timed out, it sends back a 'download response' message with an error code and subsequently resumes sending 'download request' 20 messages until downloading succeeds.

The B-channel is normally used for audio communication in this system 10. Audio is converted to digital signals and then transformed by the "DXP" PBX 65, resulting in a difference between the digital signal transmitted on the B-channel by one station 18 and the digital signal arriving at a destination station 18. In the downloading process, the B-channel is used to transmit a binary image from the loader card 52 to the station 18 being downloaded 25 to, because data can be transmitted much faster over the B-channel than the D-channel. The B-channel can transmit 64000 bits per second, whereas the D-channel can effectively transmit only about 2000 bits per second. However, to use the B-channel to transmit data, no PBX processing can be performed on the signal. So when an audio channel is opened between the loader card 52 and the patient station 18 to be downloaded to, the system 10 must essentially tell the "DXP" PBX 65 to pass the digital audio signal through without processing it.

Also, when the station 18 receives the D-channel 'prepare for download' message, it sets itself up to 30 temporarily route the incoming audio bits to a LOADER software download routine, instead of to the speaker, which is where audio is normally routed. The protocol used for the transmission of the audio data from the loader card 52 to the patient station 18 is similar in some respects to the transmission of the data from the master station PC 43 to the loader card 52 over the serial channel. There is a header sent before the rest of the data and the actual binary 35 image software data is transmitted 256 bytes at a time. There the similarity ends. Part of the difference is due to the nature of the transmission medium. The serial channel is asynchronous, meaning that at any given moment, a serial byte may be in the process of being transmitted, but for long periods the serial channel may be idle. The audio channel, on the other hand, is synchronous, and is essentially never idle. This results in a higher possibility for error 40 and loss of synchronization. Therefore, a special preamble is used to help insure that each patient station 18 recognizes the start of the header block, and another preamble is used for each 256 byte data block. Also, each data

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block has a checksum appended to it, which incorporates the loading address for that block. Finally, if the patient station 18 determines that the header block or a subsequent data block has errors in it because the block checksum test failed, it sends a "no acknowledgement" message to the loader card 52, and that block is retransmitted. A block may be retransmitted a maximum of six times before the process fails.

5 One of ordinary skill in the art will appreciate that the system described can be programmably controlled to add or remove additional features to suit the needs of the particular hospital wing in which it is used. For example, there are literally dozens of different types of calls. Some call types relate to the patient's condition, for example, calls generated from equipment monitoring the patient and code blue calls. Other call types relate to the status of equipment that the patient is using, and those calls may be either automatically or patient generated, for
10 example, status calls relating to the bathroom, shower, patient chair, etc. Further call types relate to an equipment failure or the need for equipment maintenance; and in addition, the patient may initiate a nurse call. Not only do the call types vary, but there are different groups of persons who should be notified of and respond to the calls, for example, equipment maintenance personnel, building maintenance personnel, cleaning personnel, registered nurses, social workers, emergency personnel, etc.

15 Using a data entry program at a master station, groups of persons having a common interest in a particular call are identified and stored in the system with a unique group name. Thereafter, using another data entry program the routing for each call type is entered in the system, that is, for each type of call that may be generated, the groups of persons who are to receive that call are identified and stored. Further, different types of calls will have different methodologies of cancelling the call. For example, a code blue call is a "latched" call and will remain active until
20 it is cancelled by actuating the cancel button 116 (Fig. 7) at the patient station 18 of the patient for whom the call was issued. Other types of latched calls are some types of maintenance calls which are automatically cancelled upon the equipment being fixed. Other calls are "unlatched" and are cancelled automatically, for example, a normal patient CALL answered at the master station is cancelled automatically upon the call being answered. Other "unlatched" call types are cancelled simply upon the system detecting that the call was received. In addition, an
25 interface program at the master station is used to identify the caregivers who are assigned to a particular patient, and those persons are identified with a common "Assigned Staff" group name in the system. Therefore, any call type that is to be directed to the Assigned Staff will automatically be directed to those persons specifically assigned to the patient initiating the call.

The above data links in association with the hardware illustrated in Fig. 2 permit personnel with "cordless" or "wireless" telephones to move anywhere within the hospital complex and still be in communication with the patient. For example, if a nurse or other staff person is at a remote location from the patient but wishes to talk with the patient, the system of Fig. 2 permits that person to execute the call room process illustrated in Fig. 14. The person uses a phone 64 to open a line, that is, obtain a wireless connection 69 between the phone 64 and the hospital PBX 63, and the PBX 63 provides a dial tone back to the phone 64. The person then enters an access code which causes the PBX 63 to open a selected trunk line on line 62 between the PBX 63 and the "DXP" PBX 65. The system first at 200 detects whether that trunk line has been opened and thereafter, sends a signal across the RS 232 line 57 to the master PC 43 indicating that the trunk line has been opened. The master PC, at 202 utilizes a voice card 51 to activate a prerecorded or synthesized voice along one of the lines 59, 61 back through the "DXP" PBX 65, PBX 63 and to the telephone 64. The voice message generated by the master PC 43 asks for the room number of the patient. The caller then, using the keypad of the telephone 64, enters a desired room number that identifies the
40

location of the person being called. Upon entering the room number, it is passed through the PBX 63, 65 through one of the A/D port converters 58, 60 to the voice card 51 in the master PC 43. Upon detecting at 204 that the room number has been entered, the master PC 43 then at 206 provides instructions back across the RS 232 interface 57 which cause the "DXP" PBX 65 to connect a voice communication line between the open trunk 62 and the patient room 14 (Fig. 2) identified by the entered room number. The voice communication is opened between the telephone 64 and the patient location. The patient communicates using the speaker 114 and the microphone 113 of the patient station 18. Therefore, the staff member can converse with the patient or other persons in the room. The communication occurs without the patient having to have access to or be able to manipulate a telephone. In fact, no action is required by the patient in order for the staff member to establish the voice communication link. At the end 5 of the conversation, the system detects at 208 that the caller has "hung-up", that is, disconnected the telephone 64; and the master PC 43, then instructs the "DXP" PBX 65 to disconnect the voice communication link to the patient's room. Preferably, the system includes a timer that automatically disconnects the line or "hangs up" after a predetermined period of time. That accommodates the situation where the person initiating the call forgets to disconnect the line or "hang up" after the conversation.

10 A further embodiment of the invention is illustrated in Fig. 15, which illustrates how a "nonlatched" call is initiated from a patient to the Assigned Staff. With the process of Fig. 15, when the patient pushes the nurse call button, a telephone call is automatically initiated to the appropriate one of the assigned staff. The system first, at 220, determines whether the patient has actuated the nurse call button 105 (Fig. 6) on the pillow speaker unit 22. Of course, other call buttons at other locations on the bed would also be recognized. The patient call is linked to the 15 master PC at 222 by moving across lines 68 (Fig. 2) to card cage 54, through "DXP" PBX 65, and across the RS 232 line 56 to the master PC 43, which provides a patient call to the display 34. More than one group personnel can be associated with any of the call types, and the groups can be prioritized in the system as to the order in which they are to be contacted. The system at 223 selects the highest priority group to be called next, for example, during a first 20 pass, the highest priority group is chosen. The master PC 43 at 224 then selects the person within the group to be called. If the selected group is the Assigned Staff, the master PC 43 goes to the Assigned Staff database to identify 25 and/or select the staff member to be notified of the patient call. Generally, the Assigned Staff group, as well as other groups, will have several persons identified as those who are responsible for responding to patient calls. Further, a particular group will often be assigned to several patients. Consequently, the group is subject to receiving calls from different patients, and the system must determine how those calls are to be assigned within the group. Several 30 options are available. For example, in the case of Assigned Staff, in some applications, those calls are preferably equally distributed among persons within the group. Therefore, the master PC 43 utilizes a random selection process in selecting persons within the group to whom successive calls will be directed. Further, the selection process will not select a person again until all of the persons in the group have been selected once. In other applications, the staff may be assigned a priority based on the order in which their data is entered into the system. For example, the first 35 person entered is the first person to be called, and the last person entered is the last person to be called. In that situation, the master PC 43 simply directs the call to the next person listed in the group, the group being arranged in the order in which the personnel data was entered.

At 225, the master PC 43 then determines whether the selected person has a telephone; and if so, the master PC 43 at 226 looks up the phone number of that person, and utilizing the RS 232 line 56, the master PC 40 automatically enters an access code for an outgoing trunk line 62 from the "DXP" PBX 65 to the hospital PBX 63.

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After entering the trunk access code, the master PC then enters the phone number of the selected staff person. The hospital PBX 63 causes the telephone 64 to ring, and at 230, the system detects whether the phone is answered. Preferably, the system will allow a predetermined number of rings or a predetermined period of time before it determines that the phone will not be answered. If the phone is answered, since the patient call is an "unlatched" 5 call, the call is automatically cancelled at 231. Thereafter, the master PC 43 at 232 causes a computer generated message to be transferred over one of the lines 59, 61 to the "DXP" PBX 65 across the open trunk line 62 through the hospital PBX 63 and to the phone 64. The voice message identifies the room number from which the patient call has been initiated and the call type, which in this case is a PATIENT call.

In addition, the computer generated message can optionally provide other information with respect to the 10 patient. Preferably, numerous stored recorded messages identifying special characteristics and conditions, for example, blind, deaf, mute, etc, are available; and selected messages can be assigned to a particular patient. Those messages are played back at this time, to provide the person answering the patient call with important information with respect to the patient's condition and communications capabilities. The above feature is in addition to other 15 notes can be entered into the system at the master station 32 and visually displayed using the display 34 of the master station 32.

Further, the computer generated message may provide several options to the staff person receiving the call, depending on the nature of the call type. For example, with a PATIENT call, the computer generated message at 20 232 will instruct the staff person to press the "1" key to open a voice communication link to the patient. If at 234 the master PC 43 detects that a "1" has been entered from the telephone 64, it will at 235 cause the "DXP" PBX 65 to open a voice communication link between the phone 64 and the patient station at the location from which the PATIENT call was initiated. Thus, the patient can communicate with the staff person answering the PATIENT call by using the speaker 114 and the microphone 113 on the patient station 18. The master PC 43 at 232 also provides a message that the PATIENT call will be placed on a reminder list in response to the staff person pressing the "2". If at 236, the master PC 43 detects that a "2" has been entered, it will at 238 place the PATIENT call on a reminder 25 list. Thereafter, after a predetermined period of time, either a number of seconds or minutes, the master PC 43 returns to the step 226 and reenters the access code and phone number of the selected staff person; and the process of steps 226 through 238 is repeated.

Normally, if the master PC receives no response within a predetermined period of time after the voice 30 messages have been played, it determines that the person being called is not going to respond. The process then at 240 determines whether all persons in the selected group have been called. If not, the process returns to step 224, and the next person in the group is selected; and the process iterates through process steps 225-240 as previously described. The system will also check whether all persons have been called if the selected person has no telephone as detected at step 225 or if the telephone is not answered as detected at step 230. After all persons in the group have been called as detected at 240, the process at 242 then determines whether all groups have been called. If not, the 35 process then at 223 selects the next group to be called and the process again iterates through steps 224-242; after all calls have been made the process end. It should be noted that a group, for example, Assigned Staff can be entered a multiple number of times, and therefore, the system will then cycle through the same group. Preferably, a Default group is also assigned that includes a phone number which will always be answered.

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The number of options provided by voice messages from the master PC 43 to the staff person at step 234 may be more or less, depending on the call type being processed. For example, if a CODE BLUE "latched" call is being processed, the option of placing the call on a reminder list is preferably not provided; and therefore, the person called has only the options of opening a voice communication to the patient or not responding. Further, in the event 5 of a CODE BLUE "latched" call, the process step at 231 would not be used to cancel the call because a CODE BLUE call can only be cancelled at the patient station. Therefore, with a CODE BLUE call, the process at 240 returns to step 224 to continue attempts to contact staff persons until the CODE BLUE call is cancelled at the patient station 18. Other variations of Fig. 15, depending on the type of call being initiated from the patient location may be readily implemented by those who are skilled in the art.

10 While a preferred embodiment of a patient/nurse call system 10 in accordance with this invention has been described, it is to be understood that the functional and operational capabilities of the system 10 can be varied widely to suit the particular needs of a hospital in which it is used, or even a facility other than a hospital, wherein similar communication capabilities are desired. For instance, the particular coding and prioritizing of hospital calls may be varied, along with storage and retrieval of the calls and nurse location and identification information. Moreover, the 15 manner of interfacing with the stored information at either the master station 32 or any of the patient stations 18 may also be modified. While preferably with respect to Figs. 14, 15, communication with the patient utilizes the speaker on the patient station; alternatively, the speaker on the pillow unit may also be used.

15 The invention therefore in its broadest aspects is not limited to the specific details shown and described. Accordingly, departures may be made from such details without departing from the spirit and scope of the invention 20 as claimed hereafter.

What we claim is:

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1. A patient/nurse call system comprising:
 - a plurality of transmitters adapted to be carried by hospital personnel, each transmitter periodically transmitting an identification signal unique to that transmitter;
 - a plurality of patient locations, each of the plurality of patient locations being associated with a patient and including
 - a microprocessor,
 - a receiver for receiving the identification signals from the plurality of transmitters, and
 - a microphone and speaker for audio communications;
 - a master station location remote from the patient locations, the master station location having
 - a microprocessor, and
 - a microphone and speaker for audio communications;
 - a first PBX operatively connected between the microprocessor at the master station location and each of the microprocessors at the plurality of patient locations for providing all data communications between any of the plurality of patient locations and the master station location and further providing all audio communications between the plurality of patient locations and the master station location;
 - a telephone; and
 - a second PBX connected between the telephone and the first PBX for providing a data and voice communications link between the telephone and the master station location and the plurality of patient locations.
2. The patient/nurse call system of claim 1 wherein the microphone and the speaker at the patient location are part of a patient station at each of the plurality of patient locations.
3. The patient/nurse call system of claim 1 wherein the speaker at the patient location is located in a pillow unit at each of the plurality of patient locations.
4. The patient/nurse call system of claim 1 wherein the telephone is a wireless telephone.
5. A method of providing voice communications between a staff person and a patient in a hospital comprising the steps of:
 - providing an identification number unique to a patient in response to the staff person using a telephone;
 - automatically transmitting the identification number to a hospital PBX;
 - automatically passing the identification number through the hospital PBX to a second PBX;
 - automatically passing the identification number from the second PBX to a master station associated with a location of the patient;
 - automatically opening a voice communications channel between the staff person and the patient through the hospital PBX, the second PBX and a speaker and microphone at the patient location without any physical action being required by the patient.

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6. The method of providing voice communications of claim 5 wherein prior to the step of providing an identification number, the method further comprises the step of detecting an opening of a trunk line in response to the staff person using the telephone.

7. The method of providing voice communications of claim 5 wherein after the step of automatically opening a voice communication channel, the method further comprises the steps of:

detecting the staff person terminating the call; and

closing the voice communication channel in response to the staff person terminating the call.

8. A method of providing voice communications between a staff person and a patient in a hospital comprising the steps of:

actuating a pushbutton to initiate a PATIENT call from the patient;

automatically identifying in response to the PATIENT call, a staff person associated with the patient;

automatically initiating a telephone call to a telephone associated with the first staff person in response to the PATIENT call;

detecting the telephone being answered; and

opening a voice communication channel between the telephone of the staff person and a speaker and microphone located near the patient.

9. A method of providing voice communications of claim 8 further comprising in response to detecting the telephone being answered the steps of:

transmitting a voice message to the telephone identifying the patient to the staff person;

transmitting a reply initiated by the staff person using the telephone; and

initiating a subsequent action in response to the reply.

10. A method of providing voice and data communications between a staff person and a patient in a hospital comprising the steps of:

(a) actuating a nontelephonic unit to initiate a call from the patient to a first staff person associated with the patient;

(b) detecting the call with a first microprocessor located with the patient;

(c) passing the call from the first microprocessor to a first PBX;

(d) passing the call from the first PBX to a second microprocessor at a master station associated with the patient;

(e) identifying in response to the call, a first staff person associated with the patient;

(f) initiating a telephone call from the second microprocessor at the master station through the first PBX and through a hospital PBX to a telephone associated with the first staff person;

(g) detecting the telephone being answered;

(h) transmitting a message from the second microprocessor at the master station, through the first PBX and through a hospital PBX to the telephone, the message identifying the patient and characteristics associated with the call;

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(i) transmitting a reply initiated by the first staff person using the telephone, through the hospital PBX and the first PBX and back to the second microprocessor at the master station; and

(j) initiating a subsequent action by second microprocessor at the master station in response to the reply.

11. The method providing voice and data communications of claim 10 wherein the step of initiating a call further comprises changing a binary output by actuating a pushbutton.

12. The method of providing voice and data communications of claim 10 wherein the subsequent action comprises the step of opening a voice communication channel between the telephone of the first staff person and a speaker and microphone located near the patient in response to a first reply from the first staff person.

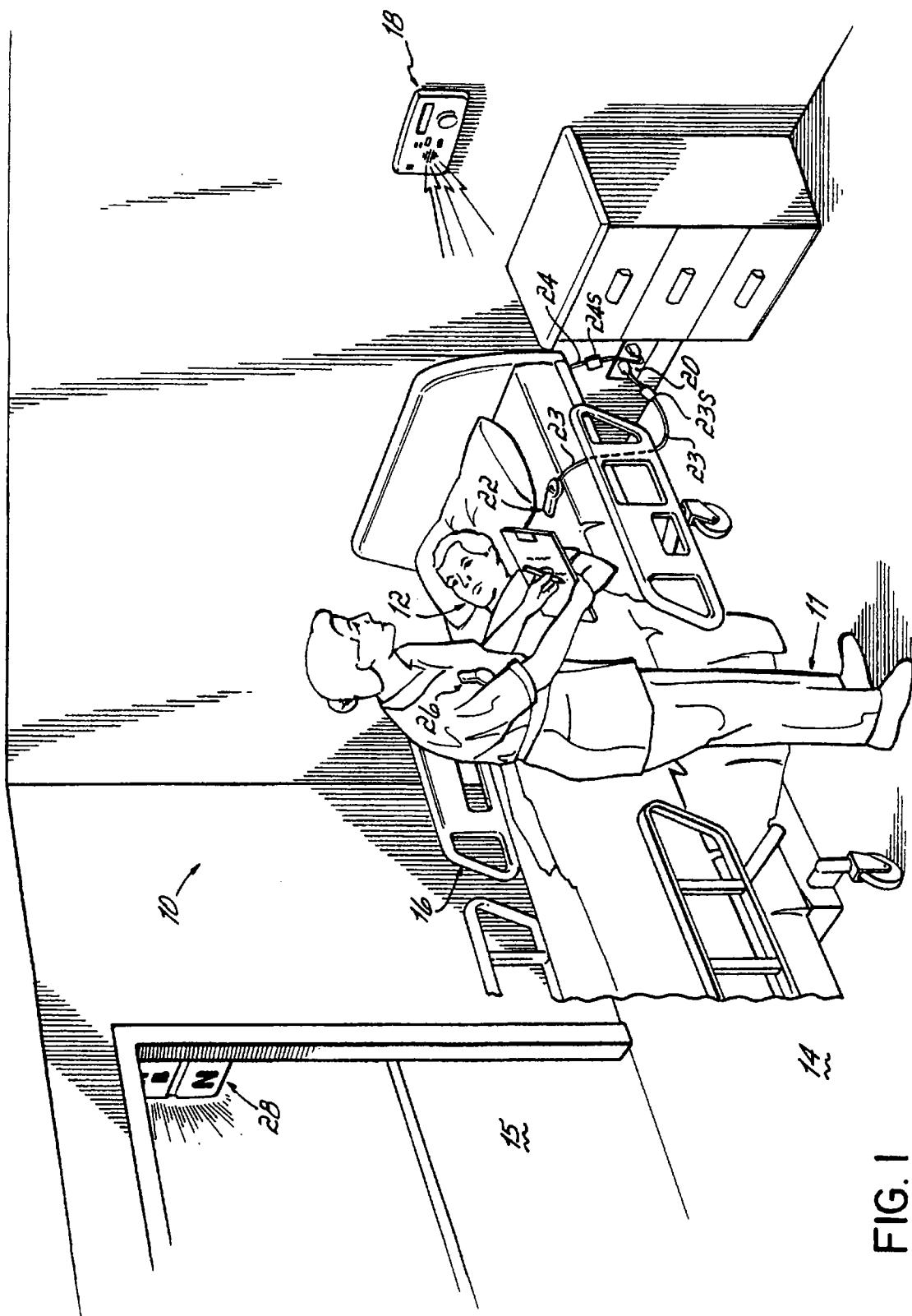
13. The method of providing voice and data communications of claim 10 wherein the call is a nonlatching call and after the step of detecting the telephone being answered, the process further comprises the step of cancelling the call.

14. The method of providing voice and data communications of claim 10 wherein the call is a nonlatching call and the subsequent action comprises the step of automatically, after a period of time, repeating steps (f) through (j) in response to a second reply from the first staff person.

15. The method of providing voice and data communications of claim 10 wherein the subsequent action comprises the step of identifying a second staff person associated with the patient in response to a third reply from the first staff person and initiating a telephone call from the second microprocessor at the master station through the first PBX and through a hospital PBX to a telephone associated with the second staff person.

16. The method of providing voice and data communications of claim 15 further comprising the steps of repeating steps (g) through (j) with respect to the second staff person.

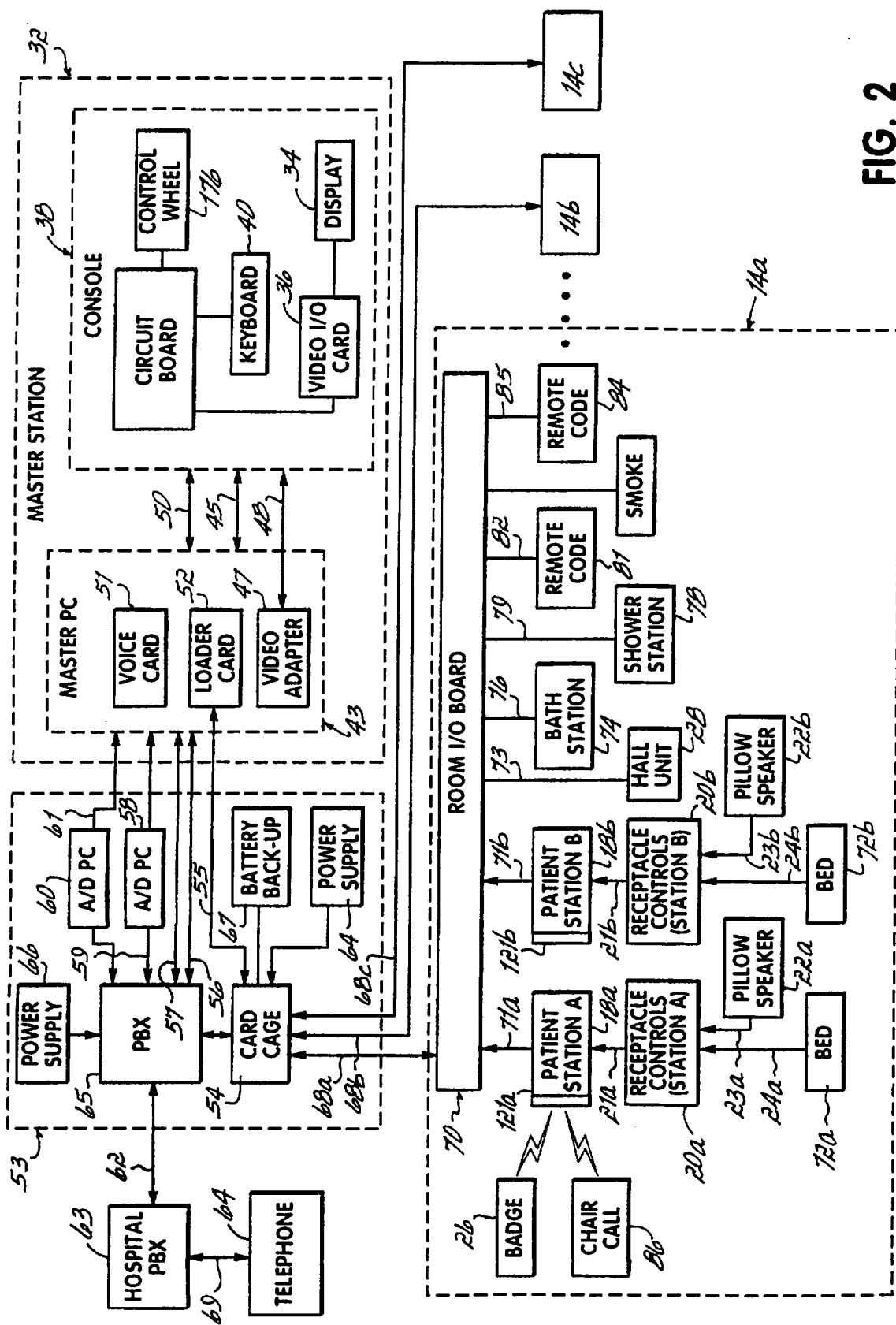
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FIG. 1

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**FIG. 2**

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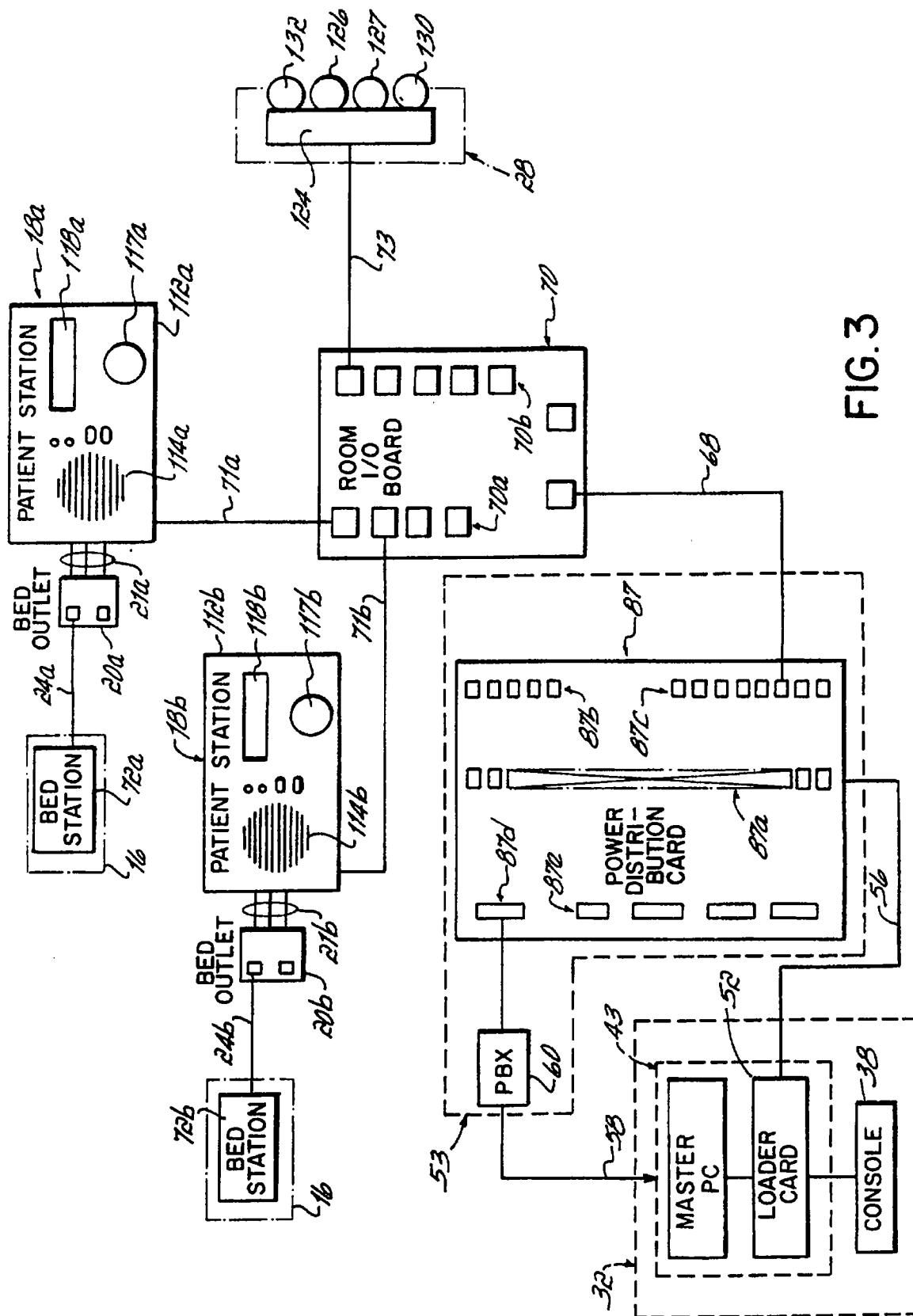


FIG.3

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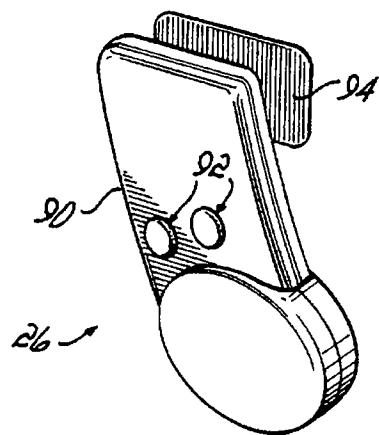


FIG. 4

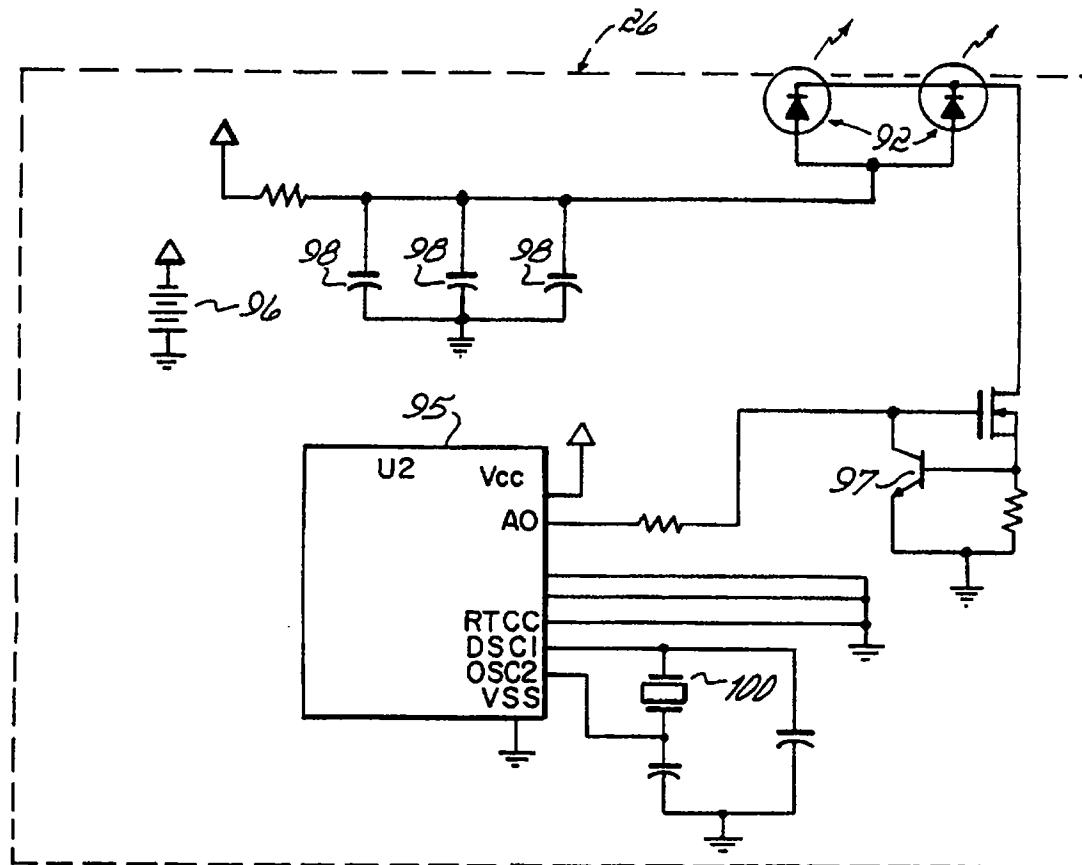


FIG. 5

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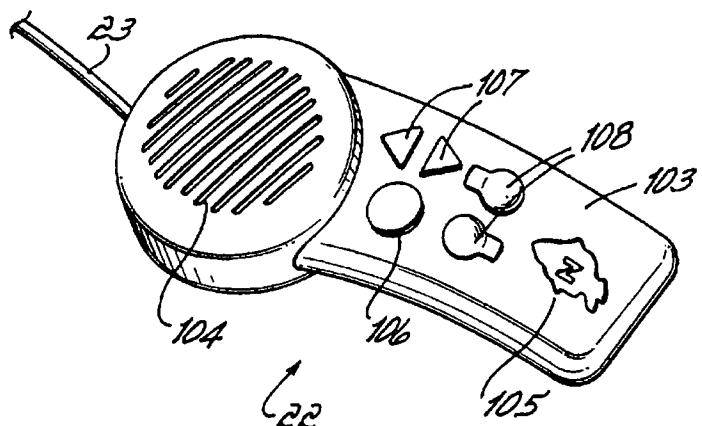


FIG. 6

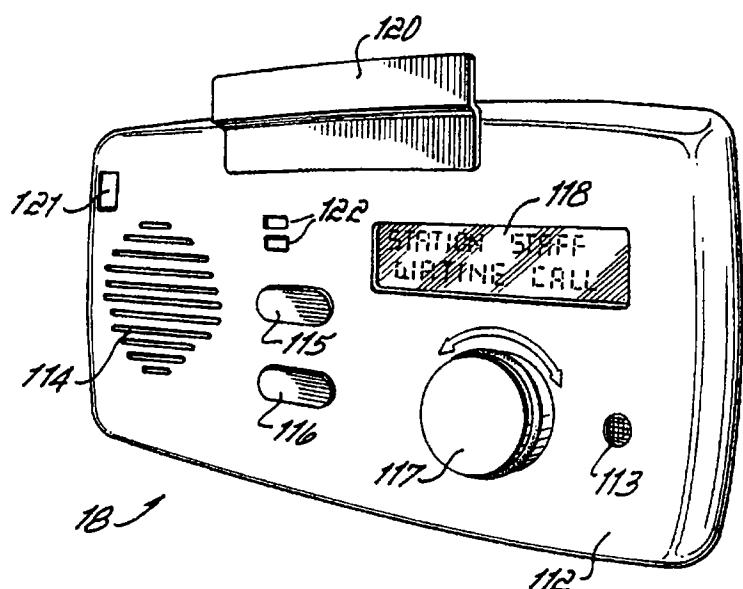


FIG. 7

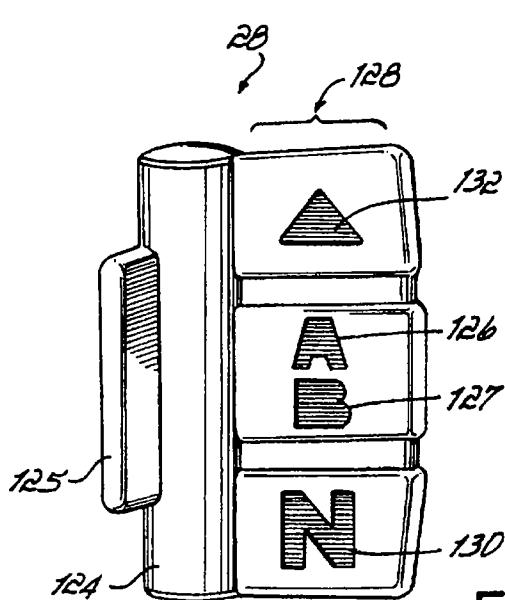
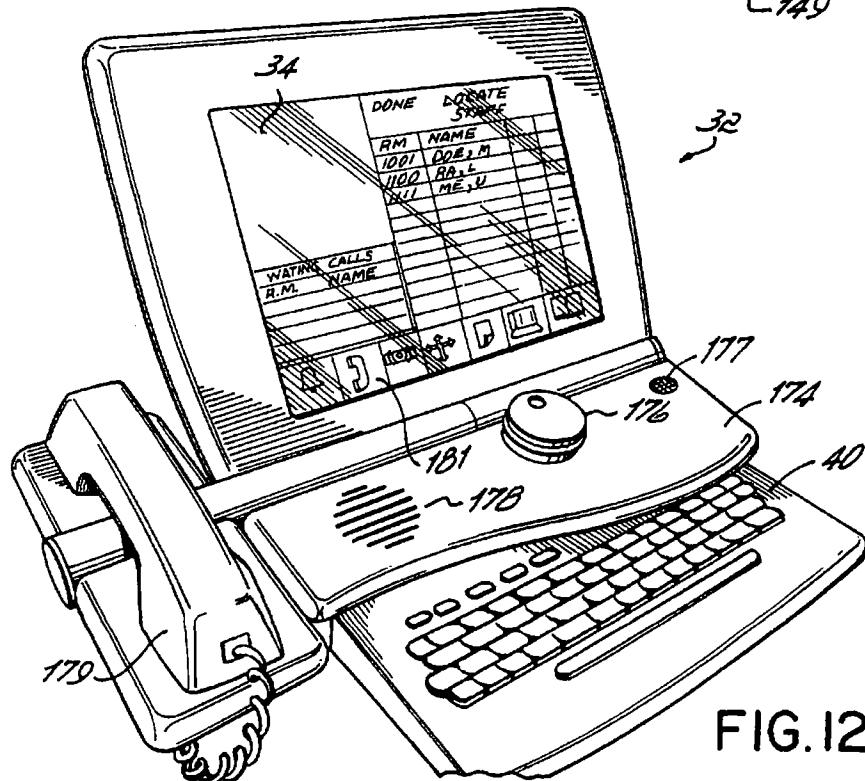
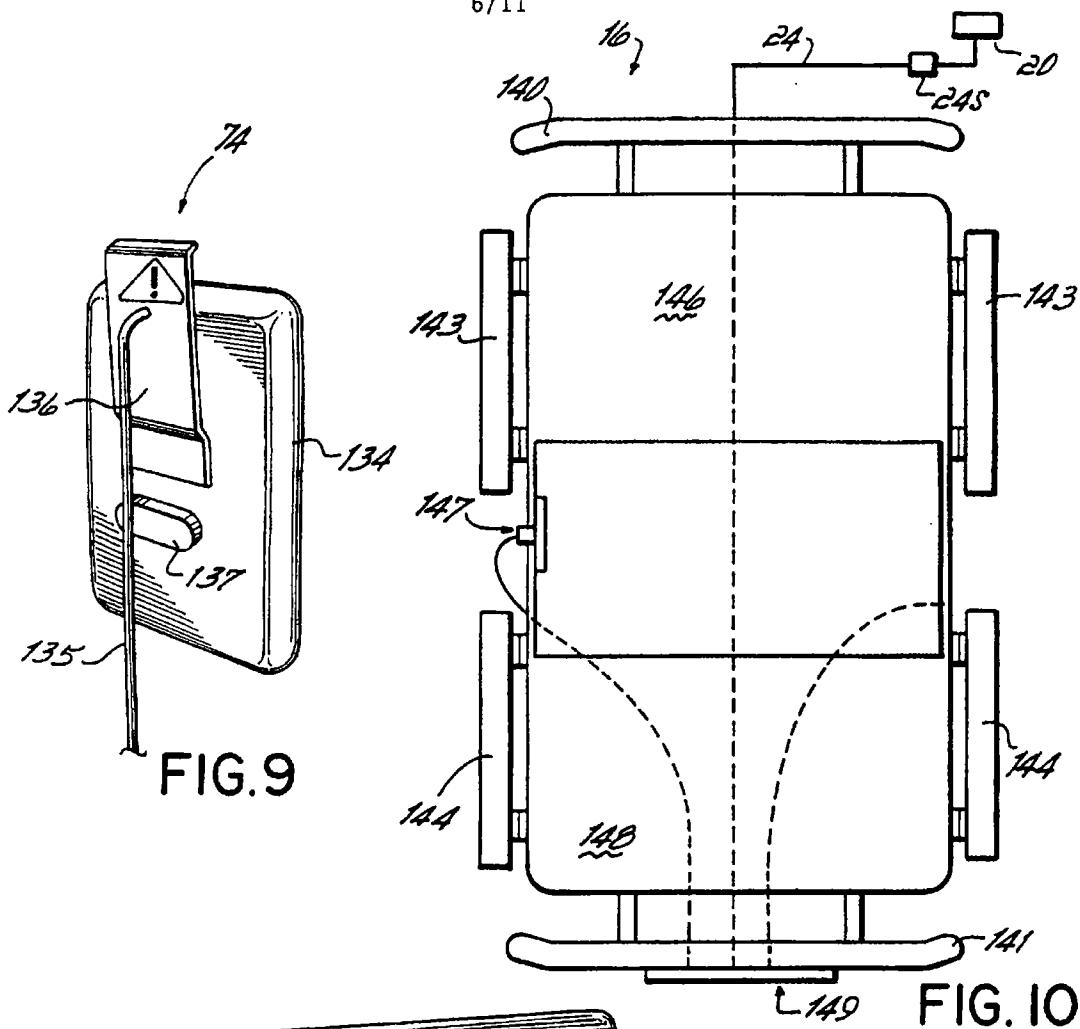


FIG. 8

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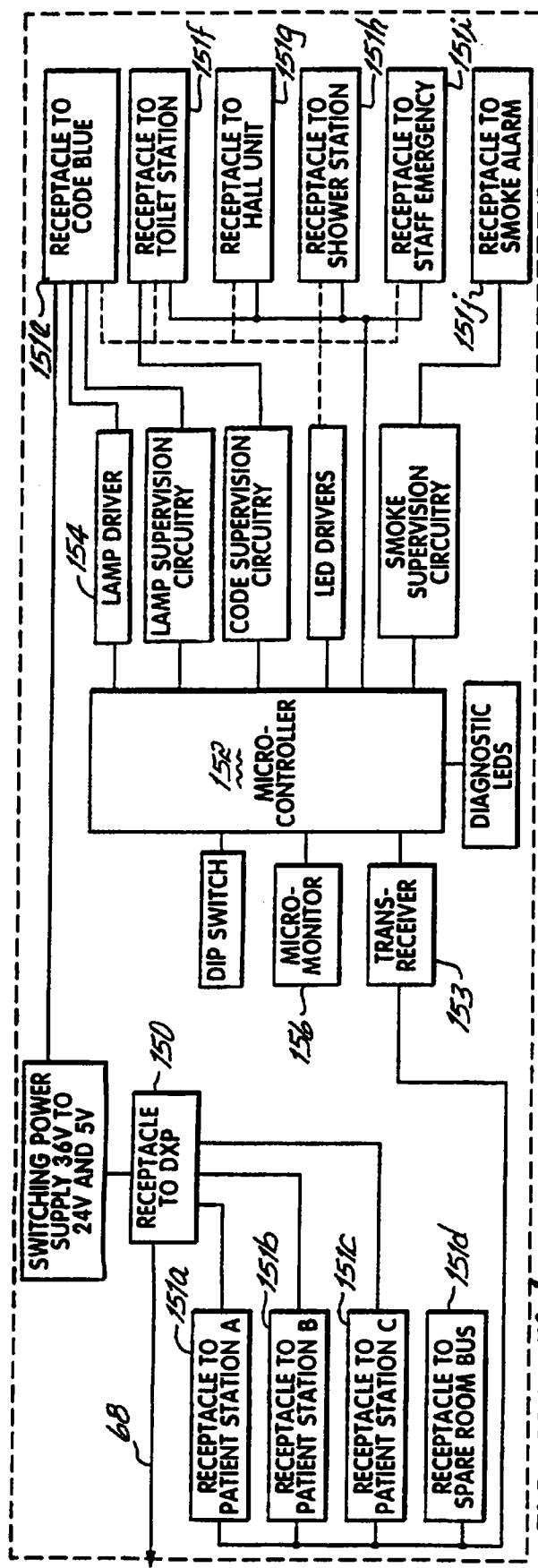


FIG. 11A

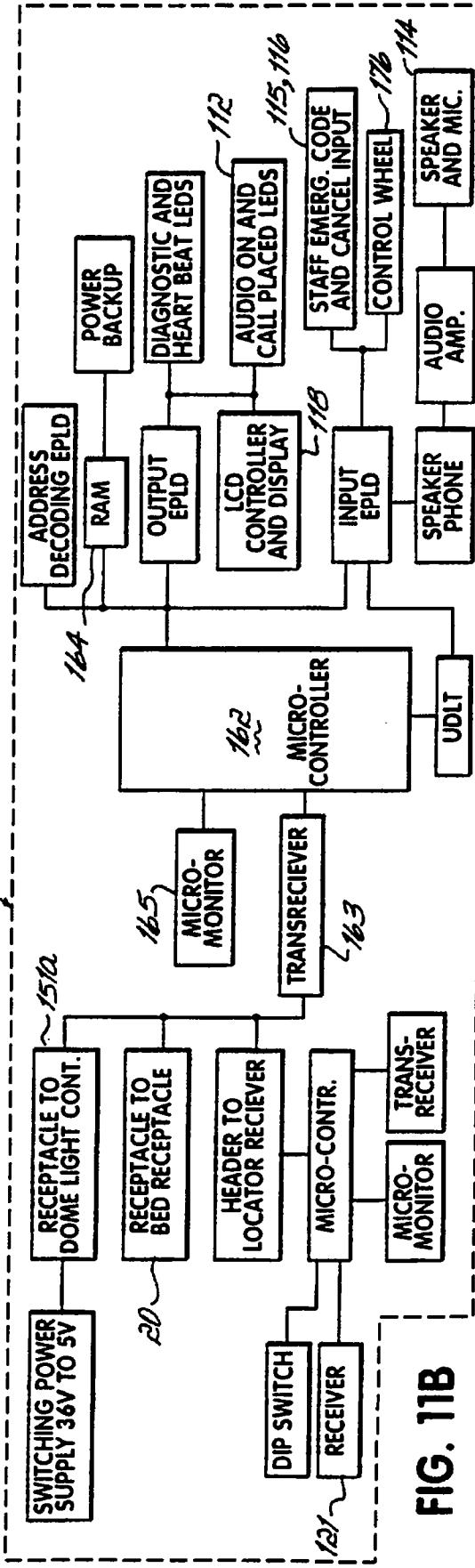


FIG. 11B

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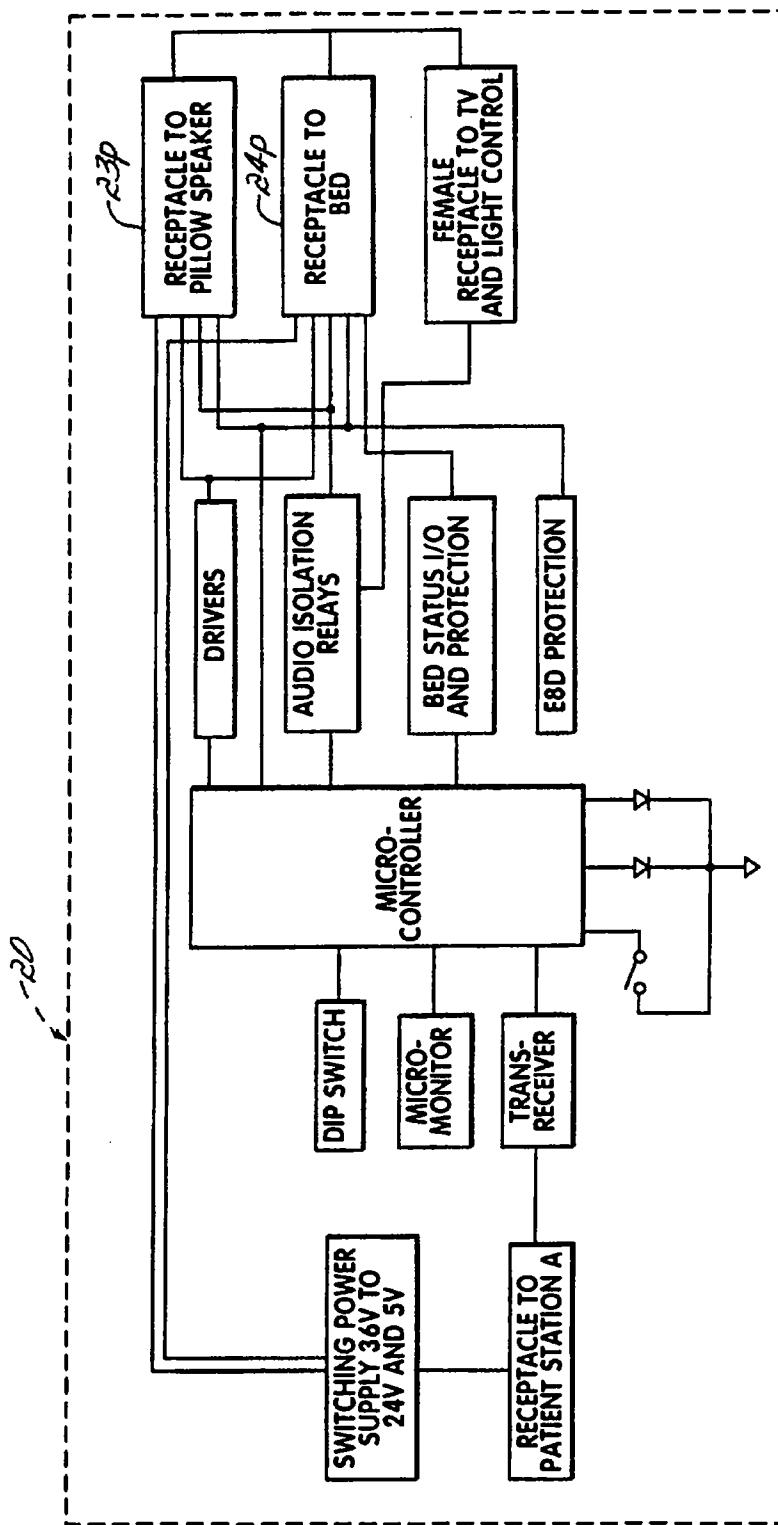


FIG. 11C

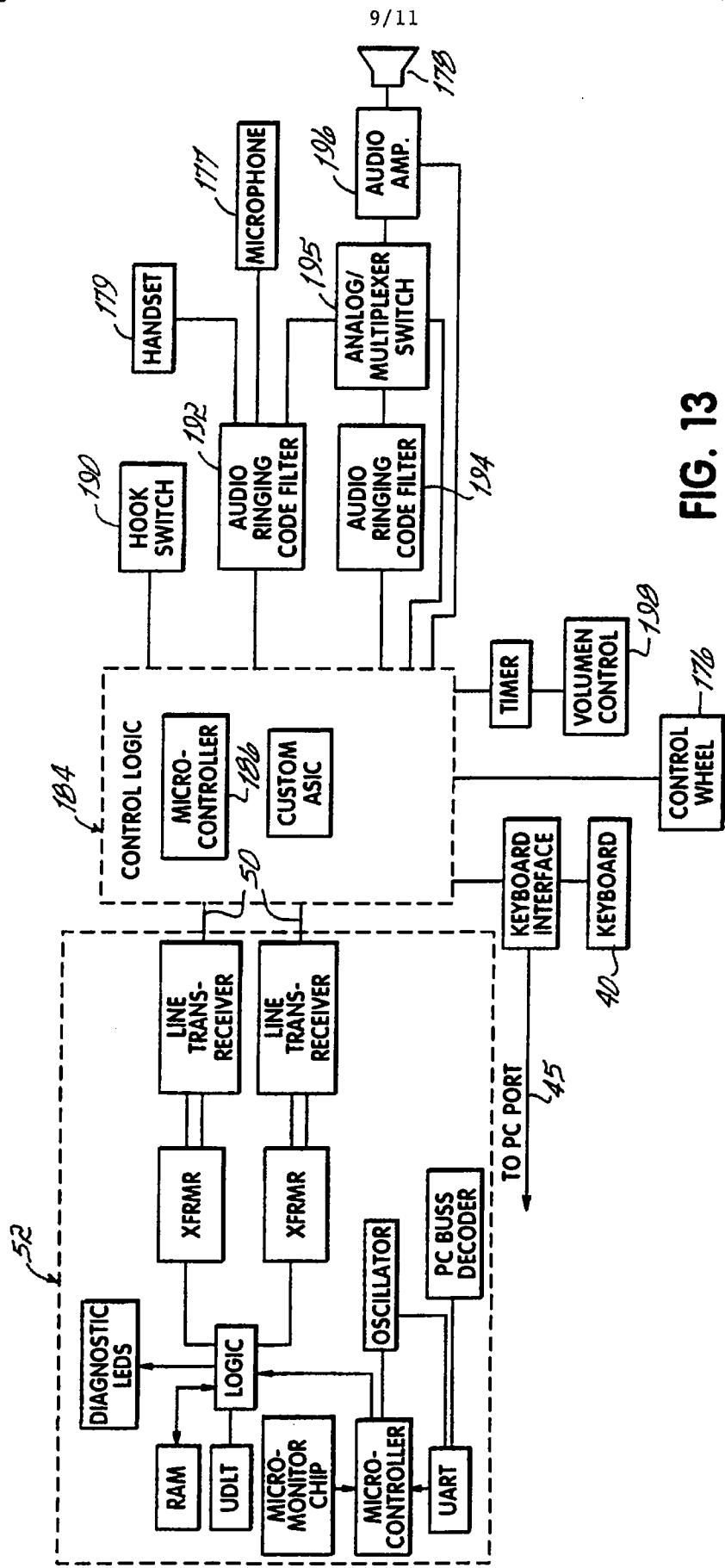


FIG. 13

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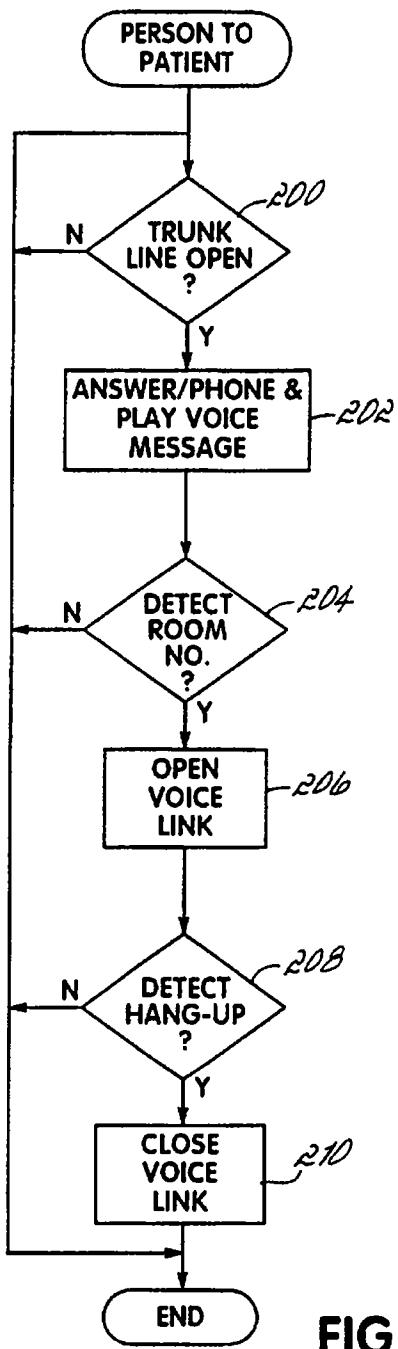


FIG. 14

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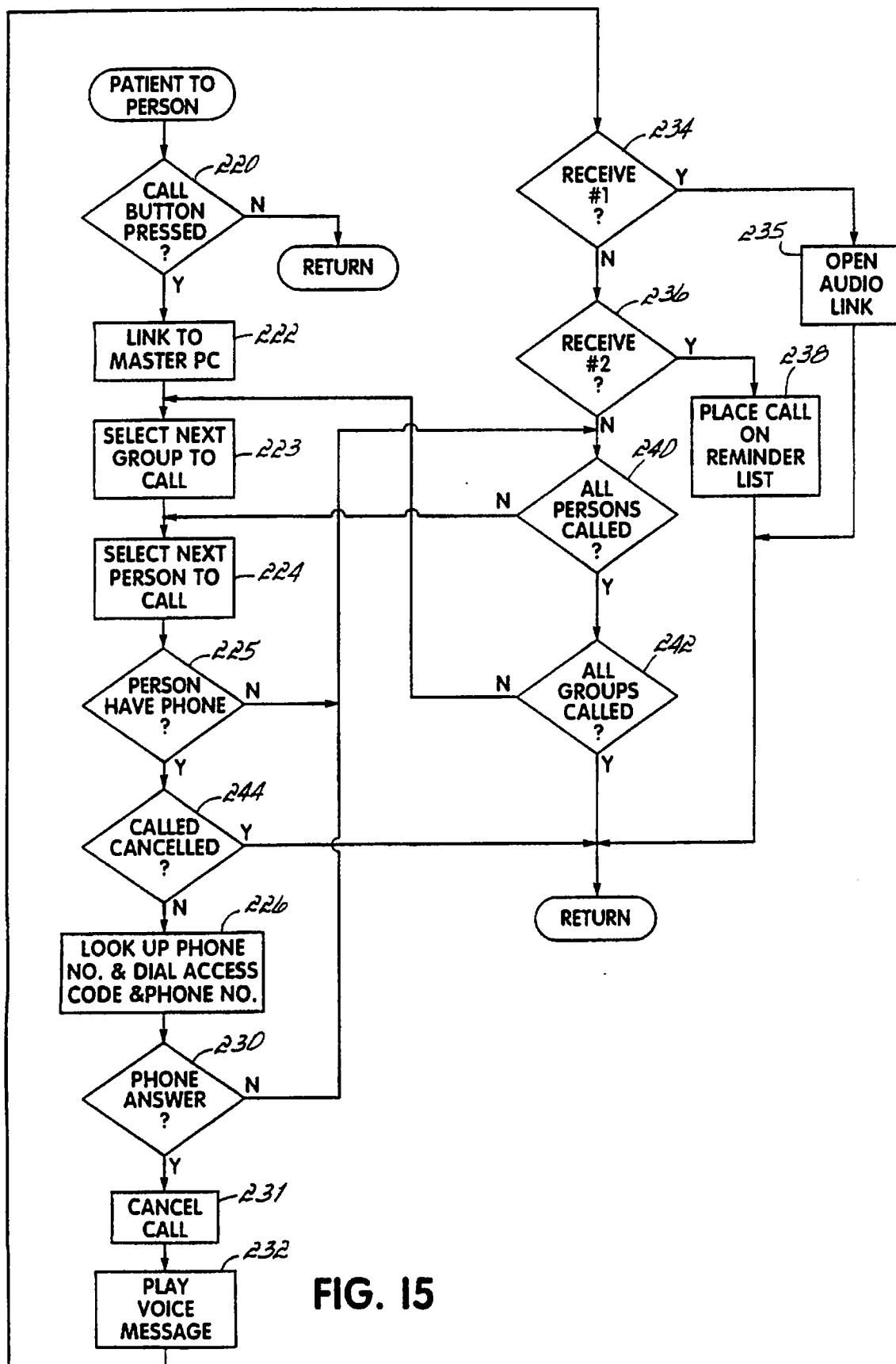


FIG. 15

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 97/14733

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G08B3/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 95 35634 A (PRICE ET AL.) 28 December 1995 see abstract; figures 1-3 see page 15, line 3 - line 16 see page 17, line 33 - page 18, line 19 see page 20, line 30 - page 21, line 10 ---	1,5,8,10
Y	US 5 291 399 A (CHACO) 1 March 1994 see abstract; figures 2-6,12,14 see column 9, line 16 - line 29 see column 10, line 41 - line 55 see column 11, line 3 - line 28 see column 16, line 51 - line 65 see column 17, line 14 - line 33 see column 19, line 25 - line 64 ---	1,5,8,10 -/-

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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- *P* document published prior to the international filing date but later than the priority date claimed

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g. document member of the same patent family

1

Date of the actual completion of the international search

14 November 1997

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/14733

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 505 627 A (ANALOGIC CORP.) 30 September 1992 see abstract; figures 1,2,6,7 see column 5, line 52 - column 6, line 11 --- US 5 062 151 A (SHIPLEY) 29 October 1991 see abstract; figures 1-3 see column 3, line 32 - column 4, line 6 -----	1,2
A		1,5,8,10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 97/14733

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 5291399 A	01-03-94	US 5594786 A US 5465082 A	14-01-97 07-11-95
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US 5062151 A	29-10-91	US 4601064 A US RE35035 E	15-07-86 12-09-95